International Marine Engineering

JANUARY, 1909

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JANUARY, 1909.

RECENT ADDITIONS TO THE ENGLISH FLEET.

With the launch at the Devonport dockyard on Nov. 7, 1908, of the battleship *Collingwood,* England now has in the water, including the ships of the *Inflexible* class, nine *Dreadnoughts.* One more will probably be launched the first of the year, and two others, which were authorized in the naval estimates of 1908-1909, will probably be laid down soon after the first of the year, so that by 1911 Great Britain will have in commission a fleet of twelve ships of the *Dreadnought* class aggregating about 169,350 tons.

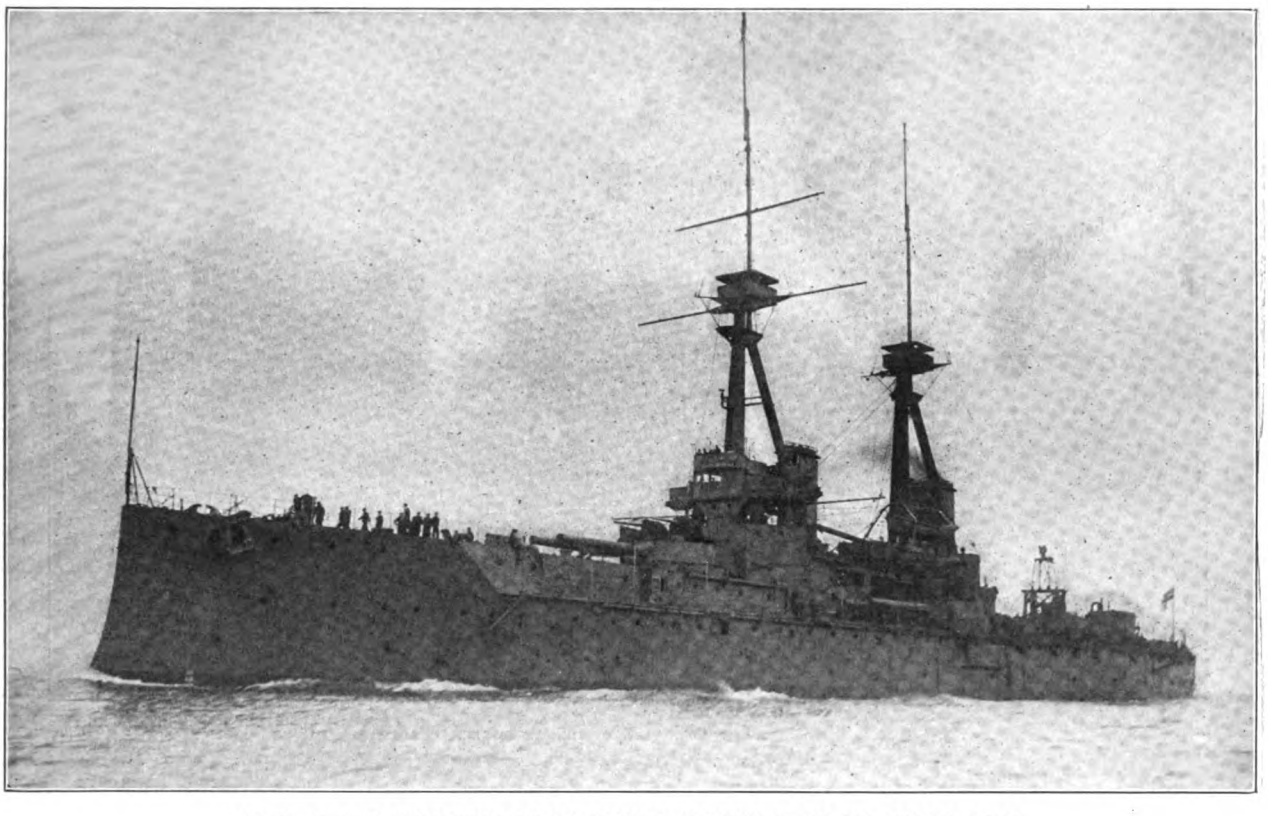

FIG. 1.—H. M. S. BELLEROPHON LEAVING PORTSMOUTH DOCK-YARD FOR HER OFFICIAL TRIALS.

The *Collingwood,* which, with the *St. Vincent* and *Vanguard,* was authorized in the naval estimates of 1908-1909, was laid down Feb. 3, 1908, and is to be completed Feb. 3, 1910. Her principal dimensions are: Length (waterline), 530 feet; beam, 84 feet; mean draft, 27 feet; with a displacement of 19,250 tons, or 1,350 tons more than the original *Dreadnought.* She is to be propelled at a speed of 21 knots by four screws, driven by Parsons turbines, the steam for which is supplied by Yarrow large-tube boilers. The total designed horsepower of the turbines is 24,500, and the arrangement of the turbines will be practically the same as that on the *Dreadnought;* that is, each of the outboard shafts will be driven by one high-pressure ahead and one high-pressure astern turbine, while the inboard shafts will have three turbines each, namely: the low-pressure ahead and low-pressure astern and cruising turbine. Provision is made for 900 tons of coal at normal displacement and 2,000 tons at full-load displacement. Oil fuel is also to be carried, and the boilers are to be equipped for burning both oil and coal.

All that can be stated definitely regarding the armor of this vessel is that the main belt is to be 11 inches thick amidships. The total number of guns which the *Collingwood* will carry has not been made public, but it is understood that her battery will consist of ten 12-inch guns, 45 calibers long instead of 50 calibers, as has been frequently reported; while her secondary battery will probably consist of sixteen or twenty 4-inch rapid-fire guns and several machine guns.

The first battleship of this class to be launched was the *St. Vincent,* which is being built at the Portsmouth dock yard. She was laid down in December, 1907, and is similar to the *Collingwood* in all respects except that she is to have Babcock & Wilcox boilers in place of the Yarrow type. The third ship of this class, the *Vanguard,* is being built at Barrow by Vickers Sons & Maxim. Work has progressed on the *Vanguard* to such an extent that she could be launched at any time but for the widening of the passageways to one of the docks. While little is known regarding the details of this ship, it is thought that she is to have a slightly larger displacement than the other two. The propelling machinery is

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to be the same as that of the *Collingwood*, with the exception that Babcock & Wilcox boilers are to be installed in place of the Yarrow type. Not only is the hull and machinery of this ship being constructed by Vickers Sons & Maxim, but the guns and armor as well, so that the entire ship down to the smallest detail will be the production of this company.

Only one of the three improved *Dreadnoughts* authorized in the naval estimates of 1906-1907 has been completed, and that is the *Bellerophon*. The construction of the other two ships of this class, the *Téméraire* and *Superb*, has been delayed somewhat on account of strikes on the Northeast coast, where the machinery is being built. The details of these ships can be stated more definitely than those of the *St. Vincent* class.

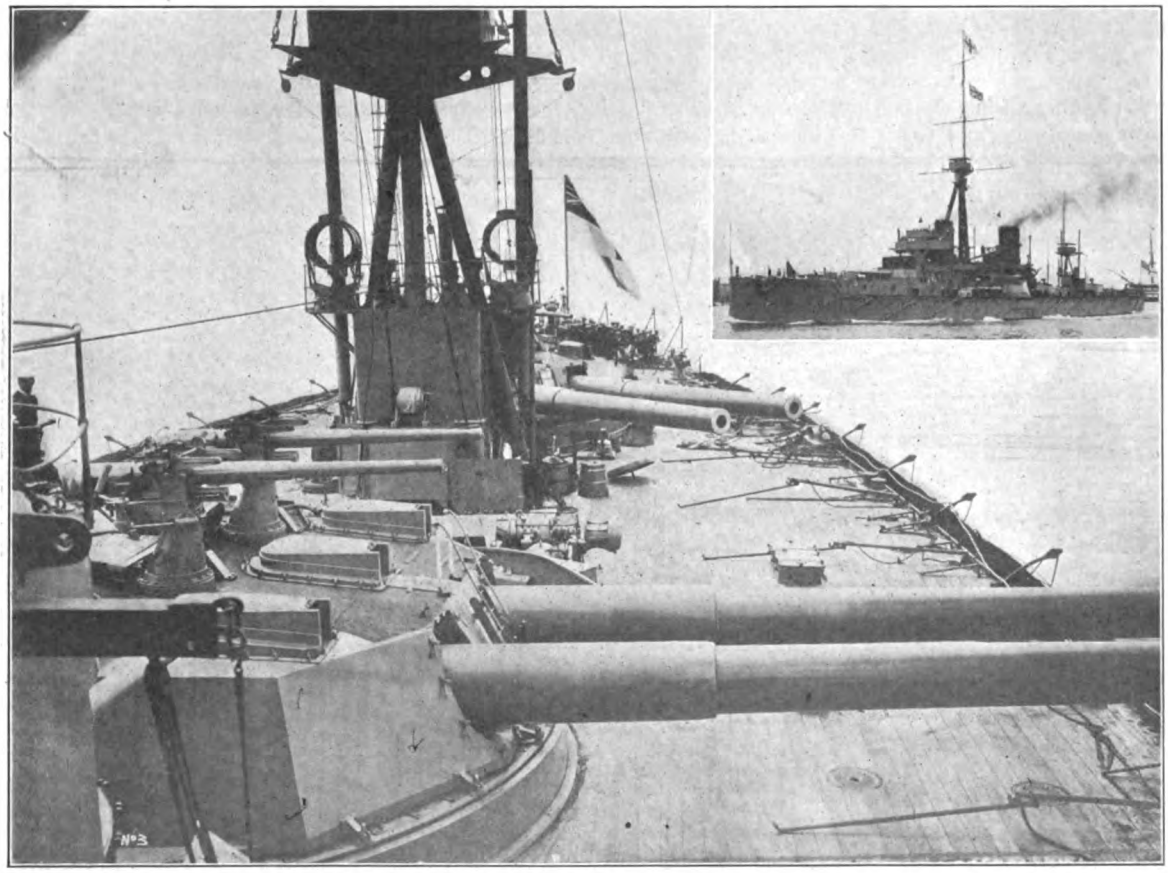

FIG. 2.—H. M. S. DREADNOUGHT AND A VIEW OF HER AFTER-DECK CLEARED FOR ACTION.

Their normal displacement is 18,600 tons, or 650 tons less than that of the *St. Vincent* class. The length on the waterline is 520 feet; the beam, 82 feet; the mean draft, 26 feet 3 inches. The armament consists of ten 12-inch guns, 45 calibers long, and sixteen 4-inch quick firers. There are four submerged broadside torpedo tubes, and one submerged torpedo tube at the stern. The waterline armor belt is 11 inches thick amidships, tapering to 6 inches forward and 4 inches aft. The upper belt is from 8 to 6 inches thick, while the turrets are protected by 8-inch armor and the barbettes by 12-inch armor. The protective deck is 2¾ inches thick on the slopes and 1¾ inches thick on the flat. The main engines of these ships are Parsons turbines, having a total horsepower of 23,000, designed to drive the ships at a speed of 21 knots. The coal capacity is the same as that in the *St. Vincent* class. Babcock & Wilcox boilers are fitted on the *Bellerophon* and *Superb* and the Yarrow type on the *Téméraire*.

It is reported that on her recent trials the *Bellerophon* attained a speed of 19 knots on four-fifths of her designed horsepower, and that on her eight-hour full-power steam trial she averaged 22 knots, the total horsepower of the turbines being 23,000.

Many rumors have been current regarding the design of the new *Dreadnought* provided for in the estimates of 1908-1909, and which is soon to be laid down at the Portsmouth dockyard. The probabilities are, however, that this ship, which is to be named the *Foudroyant*, will not be equipped with the 13.5-inch gun which many have predicted, but will retain the 12-inch gun, and in design will be simply an improved *St. Vincent* rather than a radical departure from this type. It is likely, however, that the arrangement of the 12-inch guns will be changed, not only so that all ten guns can be fired on a broadside, but also so that the guns of the middle center line turret can be fired over the after turret, as is the case on the *South Carolina* of the United States navy, and on the new Brazilian battleship *Minas Geraes*. If the turrets are to be so arranged that all the 12-inch guns can be fired on either broadside, it will mean that the two center turrets, which, in the *St. Vincent* class, are placed opposite each other on either beam, must be mounted *en echelon*, as on the *Inflexible* class. In this case it is probable that these two turrets would be on the same level as the forward turret on the forecastle. The manner in which the guns on the *Inflexible* class can be trained on either broadside is well illustrated in Fig. 4, which shows the upper deck of the *Indomitable*. The arc of fire for the guns arranged in this way is somewhat limited when trained across the ship, but it is sufficient to make them available for broadside fire.

Turning now to the powerful cruisers of the *Inflexible* class, which we have included in the squadron of *Dreadnoughts* on account of their great speed and heavy gun power, we find that, with the exception of the one provided for in the estimates of 1908-1909, all of these battle cruisers have been

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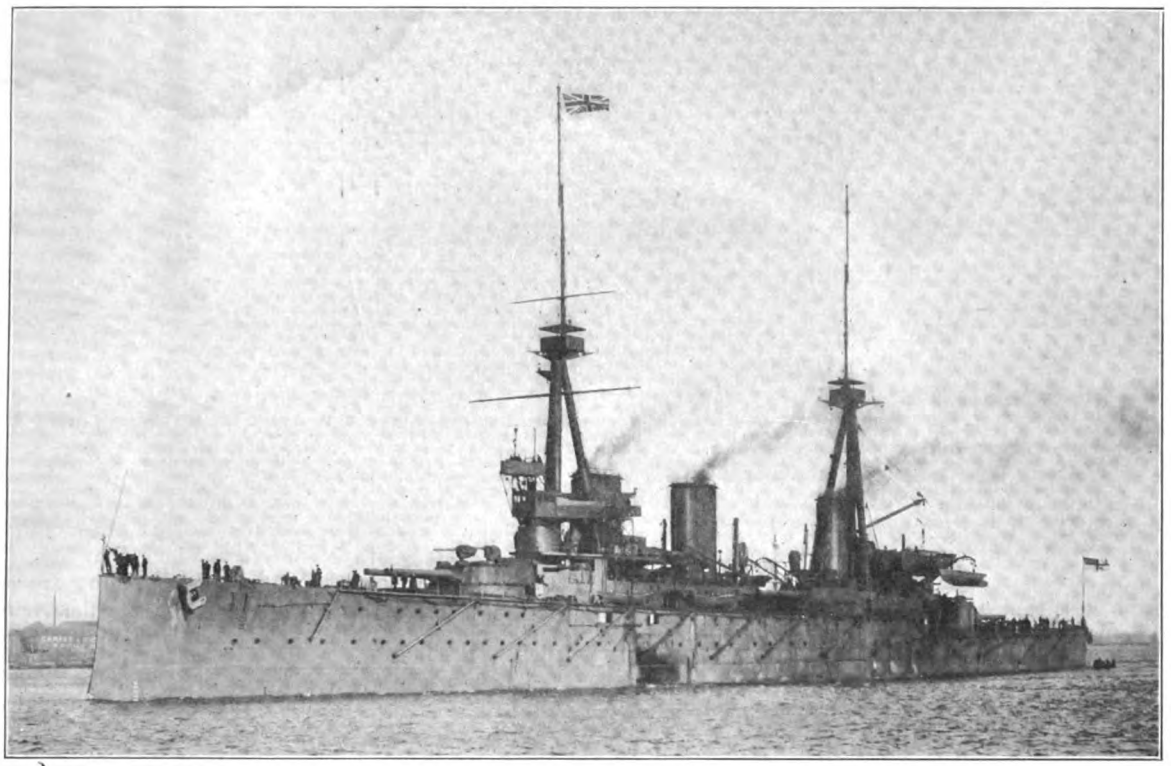

FIG. 3.—THE BATTLE CRUISER INDOMITABLE.

completed and have finished their trials. The *Indomitable,* which has been described at some length in previous issues of this magazine, has been in service long enough to attain a world-wide record for speed. The *Inflexible,* built at the Clydebank yards of John Brown & Company, was commissioned Oct. 20 at Chatham; while the *Invincible,* built by Sir W. G. Armstrong, Whitworth & Company, Newcastle-on-Tyne, has just carried out her trials. She is reported to have attained a speed of 25 knots on seven-tenths of her full power, and a speed of 28 knots on her eight-hour full-power trials.

These ships are not only the longest warships afloat but also the fastest and most heavily armed cruisers in the world. Their displacement is 17,250 tons; they have a length on the waterline of 560 feet; a beam of 78½ feet, and a draft of 26 feet. Parsons turbines, designed for a total horsepower of 41,000, have been installed in each ship, steam being furnished by Yarrow watertube boilers in the case of the *Inflexible* and *Invincible,* and Babcock & Wilcox boilers in the case of the

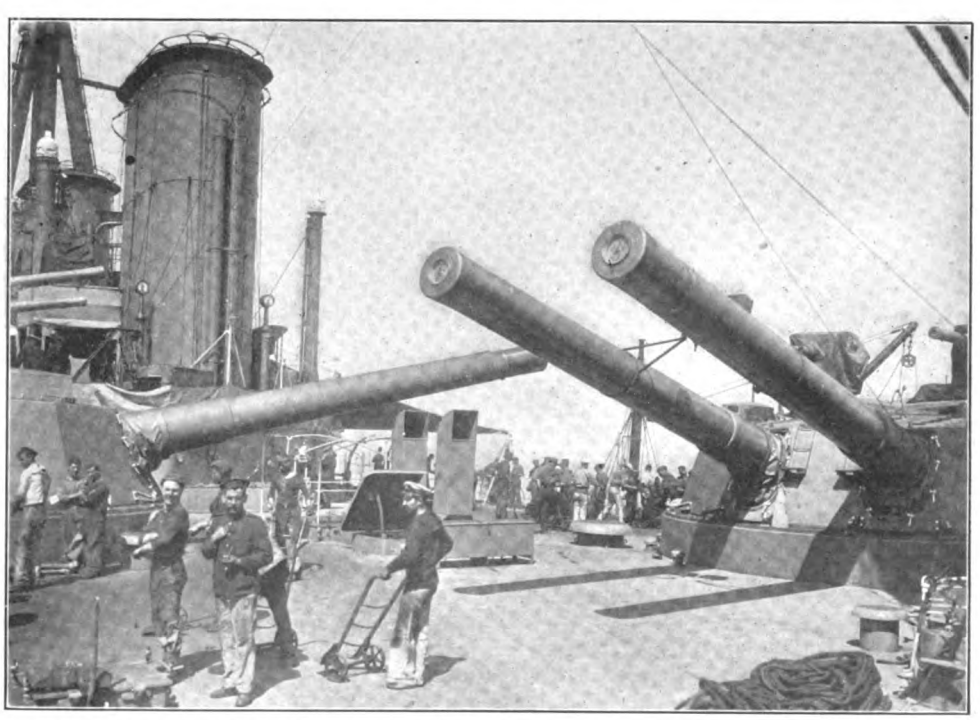

FIG. 4.—UPPER DECK OF THE INDOMITABLE, SHOWING MANNER IN WHICH 12-INCH GUNS CAN BE TRAINED ACROSS THE SHIP.

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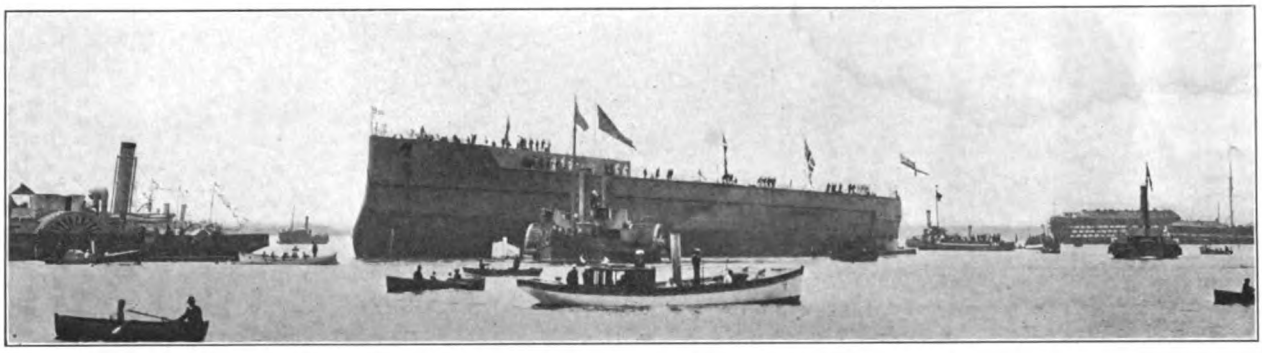

FIG. 5.—LAUNCH OF H. M. S. ST. VINCENT AT THE PORTSMOUTH DOCKYARD.

Indomitable. Designed for a speed of 25 knots, all three ships have greatly exceeded this speed on their trials. The normal supply of coal is 1,000 tons, and the maximum supply, 2,000 tons; oil fuel is also carried, and the boilers are designed to use oil in conjunction with the coal.

The armament of these vessels, which is the main reason for classing them as *Dreadnoughts,* consists of eight 12-inch guns 45 calibers long, mounted in pairs in turrets, so that all eight guns can be fired on either broadside, and six of them either directly ahead or directly astern. The secondary battery consists of sixteen 4-inch rapid-fire guns and also three submerged torpedo tubes. The heaviest armor is 7 inches thick at the waterline amidships. This tapers to 4 inches at the bow.

It is interesting to note that the old *Inflexible,* which was a ship of 11,880 tons, 13 knots' speed, built in 1875, was one of the first warships to have her guns mounted *en echelon.* She carried four large guns in pairs in turrets, the starboard pair being ahead of the port pair. This condition is repeated in the new *Inflexible* and her sister ships, where the center turrets are mounted in this manner. In the new *Inflexible,* however, this arrangement permits the guns to be fired on either broadside, whereas in the older ship this was not possible.

Building Slips for the New White Star Liners Olympic and Titanic.

The preparations which are being made in the Belfast yard of Harland & Wolff for the building of the largest vessels afloat are noteworthy. The new White Star Liners' gross tonnage will each approximate 42,000 tons, with a displacement of 60,000 tons, as against 17,274 tons gross of the *Oceanic* and 31,938 tons of the *Mauretania.* The cost of the new liners will exceed by £50,000 ($243,325) that of the big Cunarders.

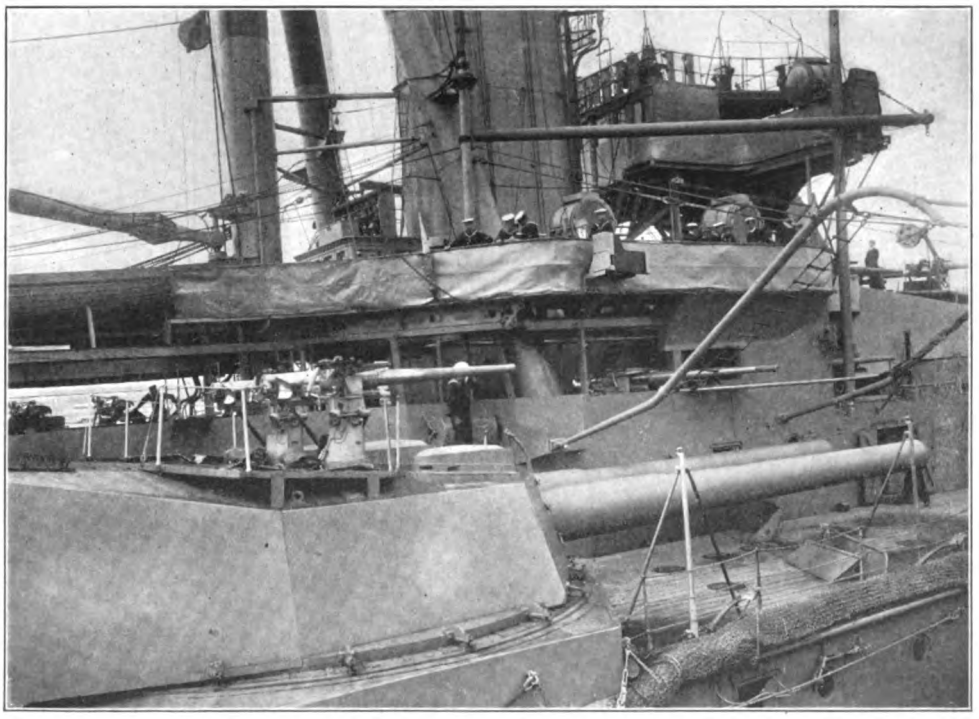

FIG. 6.—SIDE TURRETS AND BRIDGE DECK OF THE DREADNOUGHT.

The alterations and additions which have been in progress at the yard since October, 1907, include an enormous double gantry over the two new slips on which the keels are to be laid, the erection of a floating crane, and the introduction of the most modern hydraulic and pneumatic plant, electrically driven. Improvements have also been carried out in various departments of the shipbuilding and engineering sections.

The great double gantry is now nearing completion in the north yard, which is to be utilized in the building of the hulls. This structure, which has been erected by Sir William Arrol & Company, Glasgow, the builders of the Forth Bridge, consists of three vertical steel structures, placed directly over the three berths on which the firm's largest vessels have been

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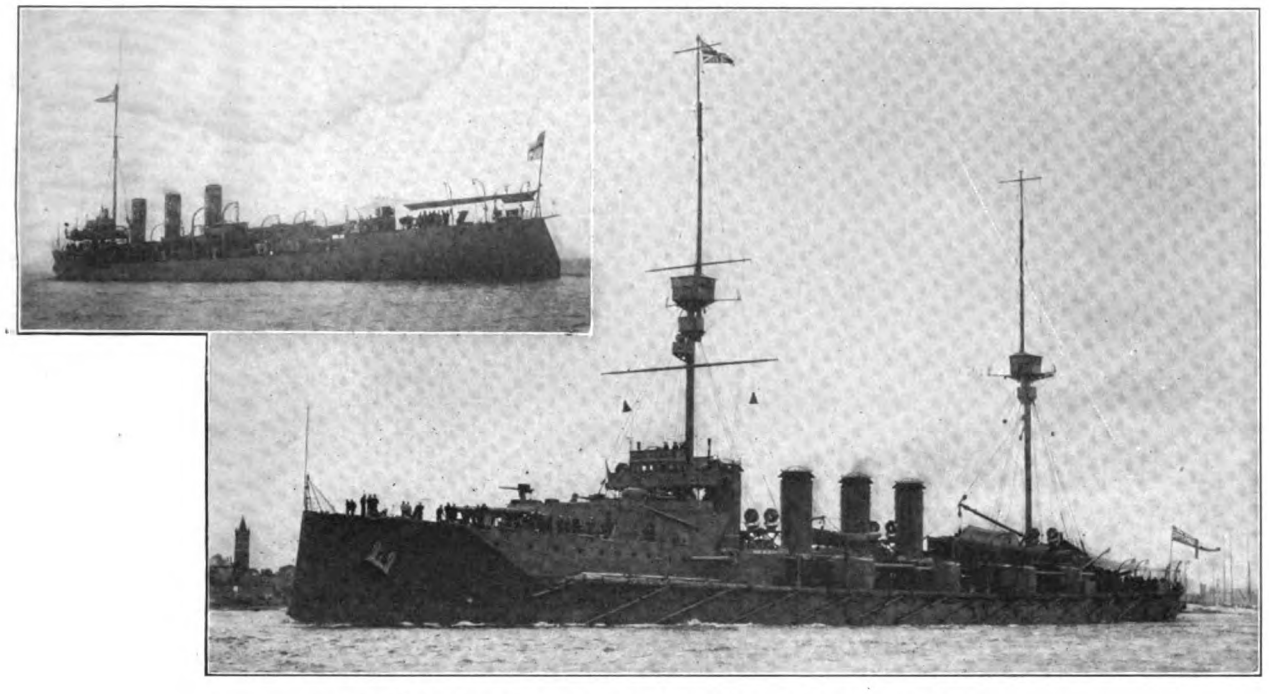
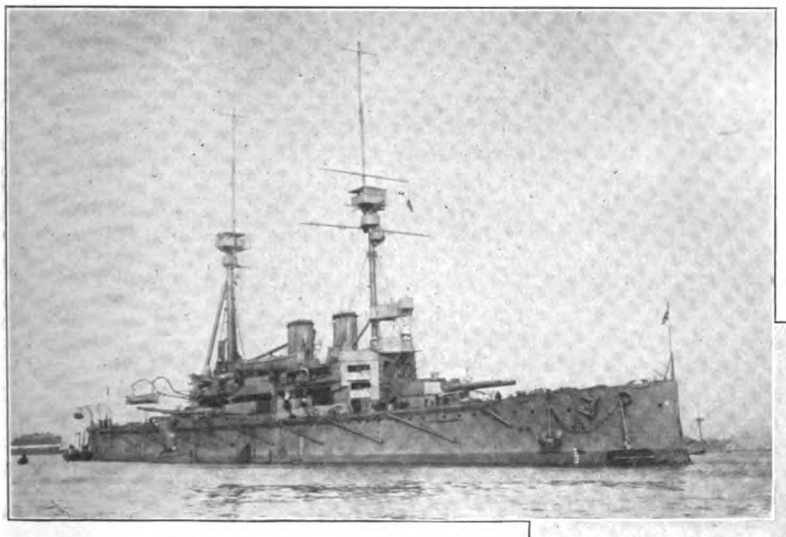
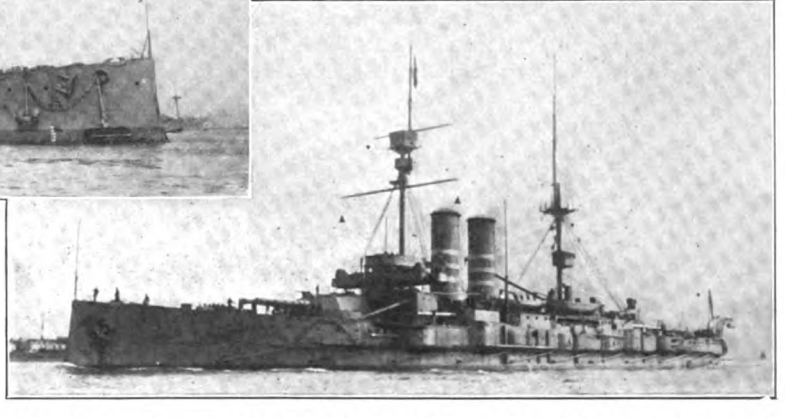


FIG. 7.—25-KNOT SCOUT CRUISER FORWARD AND ARMORED CRUISER MINOTAUR.

built. These three bays are being converted into two. The framework has a total length of 840 feet, with a width of 270 feet. From the yard level to the top of the cantilever crane which surmounts the structure the distance is 230 feet. The framework columns are of lattice construction, and are 80 feet apart, with girders connecting them longitudinally. The double gantry carries twenty-three cranes, electrically driven, so placed that any part of the berths can be easily reached. The cantilever runs the entire length of the gantry, and is capable of lifting 3 tons at a stretch of 135 feet and 5 tons at a stretch of 65 feet, and carrying the loads to a height of about 180 feet from the ground at any point within a radius 1,070 feet long by 285 feet wide. The speed capacities are: Lifting, 250 feet; slewing, 400 feet; traveling, 200 feet, and cross traverse of the truck on the crane, 150 feet per minute. There are three overhead travelers above each berth, and each of them carries two cranes capable of handling 10-ton trucks. At a lower level there are five side-walking cranes on each gantry, with jibs of 50 feet radius, each carrying 5 tons. Two of the higher level cranes nearest the water are fitted with eyes to lift 40 tons, and these will deal with stern frames and propeller brackets. The collective strength of the motors which drive the cranes is 1,600 horsepower, and 7,000 tons of steel have been utilized in the construction of the framework



BATTLESHIP BRITANNIA, OF THE KING EDWARD CLASS.



BATTLESHIP AGAMEMNON, OF THE LORD NELSON CLASS.

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alone. The length of the two berths covered by the gantries is 1,000 feet each, and there is ground space between the north and south yards to extend them when necessary.

The construction of the berths is interesting from the point of view of magnitude. Some 10,000 piles have been driven; the piles, which are of larch, pitch pine and Oregon pine, varying in length from 30 feet to 40 feet. Near the water's edge an enormous dam has been fixed to the piles by powerful steel rods, while the tops of all the piles are reinforced by steel girders and old rails. A sheet of concrete envelops the entire surface, and at some parts it attains a depth of fully 4 feet, the incline given to the beds being sufficient to ensure launching at a safe speed.

DOCKYARDS VERSUS CONTRACTORS.

The British shipbuilding trade and those "in the know" connected with it are much interested in two recent events. One is that the Admiralty have just placed contracts with private builders in England and Scotland for five second-class cruisers and seven destroyers. These cruisers are to be of 4,000 tons displacement each, and will have turbine-propelling machinery designed for a speed of not less than 25 knots. The destroyers are to have a speed of 27 knots. Of these cruisers three are to be built on the Clyde (by Fairfield Company, John Brown & Co., and William Beardmore & Co., respectively), one by the Armstrong-Whitworth Company, Elswick-on-Tyne, and one by Vickers Sons & Maxim, Barrow. Of the destroyers, two are to be built on the Clyde (by William Denny & Bros., and the London & Glasgow Shipbuilding & Engineering Company), one by the Thames Iron-Works Company, one by Hawthorn, Leslie & Co., Tyne; one by J. I. Thornycroft & Co., London, and two by White & Co., Cowes. The cruisers will cost about £350,000 ($1,703,300) each, and the destroyers about £100,000 ($486,650) each, so that a total sum of about two and a half millions sterling ($11,900,000) is involved in these contracts.

The second item of interest is that the *Indomitable*, whose famous race across the Atlantic only a few short months ago won the applause of the world and the envy of other maritime nations, has proved a perfect disappointment after passing through Admiralty Dockyard hands at Chatham for overhaul since her return from her record-breaking voyage.

Now what is the connecting point of interest between these two items of intelligence? It is spelt in a single phrase, "Admiralty overhaul." Nobody, anywhere, doubts for a single moment that each one of the private firms will deliver the vessels recently contracted for fully up to, and even beyond, the Admiralty requirements. What the Fairfield Company, for instance, proved that they could do in the case of the *Indomitable* they will not fail to do with the new cruiser they are to build. And what the *Indomitable* could do, even before her world-famous Atlantic run, was shown by the data from her official trials which were published in the August, 1908, issue of this magazine. The speed contracted for was 25 knots, and on her official steam trials she averaged 26.75 knots, and on her long ocean run she averaged considerably over 25 knots. Since, however, she came out of Chatham hands, her speed has dropped notoriously—even to the extent (though a judicious official silence is maintained on the subject) of 5 knots below the rate contracted for.

This vessel was only taken over by the Admiralty after she had passed through a long course of official trials. These trials proved that she was perfect in every respect and more than up to contract, when handed over and formally accepted. She was placed in commission, and on her first voyage more than demonstrated the ability of the builders, and the wisdom of the Admiralty in accepting delivery. She came back from her voyage, was taken out of commission and sent to the Admiralty Dockyard at Chatham. If, then, she has now proved a failure or a disappointment in any respect, the *whole blame must be with the Admiralty*. And that is why the new contracts are being regarded askance. It is absolutely certain that the vessels now contracted for will have the desired speeds when handed over to the naval authorities, but what will they be afterwards? The new cruisers, like the *Indomitable*, are to be turbine ships, and Chatham is not the only place where they seem to know nothing about turbines.

The *Indomitable* is in more senses than one "The Ship of Mystery," as she has frequently been characterized. She is a wonderful ship, but not the least wonderful thing about her is, that she has demonstrated to Admiralty officials the grand old "circumlocution office" principle of "how-not-to-do-it." Why she was taken to bits when she was sent to the dockyard nobody knows—outside Whitehall or Chatham. If her turbines needed overhaul, the proper people to do it were the builders of them, who knew all about them—not the dockyard hands, who know nothing about turbines, and probably not much about engines of any kind. The case, indeed, just serves to revive the old complaint that contract machinery is taken to pieces at the Admiralty Dockyards just to enable the Admiralty engineers and officials to instruct themselves in their own profession—by finding out how cleverer and more experienced men do their work. The instruction is doubtless necessary and valuable—but it is extremely expensive. It is open to doubt if a contract-built ship ever went through a dockyard overhaul without coming out the worse for it. That is to say, these Government officials are much better at taking a contract engine to pieces than they are at putting it together again. If all tales are true, the *Indomitable's* turbines were more than they could manage, and yet they are about to attack the *Inflexible* in a similar manner.

It seems about time the British public wakened up to the way in which their money is being wasted at these Government establishments. A good many people in the shipbuilding trade think it would be better, and certainly cheaper, for the country if these establishments should be shut up altogether. The instance cited seems to confirm that view. Many people think it would be unwise to shut up the Government Dockyards altogether, maintaining that they should be reserved for repair work only—not for constructive work. It is just in this so-called repair work, however, that they are doing the mischief—spoiling the handiwork of people who do know their business, in order to instruct people who do not know it.

The writer is giving voice to a standing grievance in the British shipbuilding trade. It is not the engines alone that are, or may be, ruined by the pottering about and tinkering of amateurs who would be experts, but all sorts of details are interfered with. A private builder knows exactly where to get the best of everything he needs for his engine room, his boiler room, his stokehold, his shaft tunnels, and so forth. He doesn't need any Admiralty official to teach him where to get the best material for his purpose, but whenever the Admiralty official gets his finger in an overhaul he can reject wholesale—at the public expense—this, that and the other detail carefully thought out and judiciously provided by the contractors, in order to replace it with some fancy pattern supplied by some friend of his own. Each of these little details—as, for instance, boiler covering—may be small in itself, but in the aggregate they mount up and unconsciously swell the Admiralty estimates for repairs. And the trouble is, that with so much waste of money, the dockyard repair too often spells misfit.

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MARINE ENGINE DESIGN.

BY EDWARD M. BRAGG, S. B.

STEAM SPEEDS AND VALVE DIAGRAM.

The steam speeds commonly given for engines are based upon the piston displacement. The volume of steam entering a cylinder is assumed to be the volume given by the product of the piston speed and the area of the cylinder. Steam speed

$$= \frac{A \times PS}{a},$$

where A is the area of the piston in square inches, and a is the area of the passage in the same units. The width of the port in the direction of motion of the valve should be from 0.6 to 0.8 of the eccentricity.

The eccentricity is usually given in inches, half inches, or quarter inches, so it is well to start the solution of the valve gear problem by assuming an eccentricity appropriate to the size of the engine.

I. H. P. of engine	500 to 1,000	1,000 to 2,000	2,000 to 5,000	5,000 to 10,000

Eccentricity:

H. P. and M. P.....	3″ to 3½″	3½″ to 4″	4″ to 4½″	4½″ to 5″
L. P.....	3″ to 3¾″	3½″ to 4¼″	4″ to 5″	4½″ to 5¼″

In order that the low-pressure valve may not be too broad, when a slide valve is used, it is sometimes necessary to make the valve double ported, and to increase the eccentricity. The breadth of the passage, going from the face of the slide valve to the cylinder, must be not more than 0.85 D to 0.95 D, where D is the diameter of the cylinder. The port area necessary will depend upon the steam speeds, and the steam speeds must be selected with reference to the desired economy. The steam speeds should be about as follows for engines whose design factor is 0.7 or more:

Main steam pipe.....	6,000 to 7,200 feet per minute.
Throttle valve.....	5,000 to 6,000 feet per minute.

	High-pressure Ports.	Medium-pressure Ports.	Low-pressure Ports.
Entering steam.....	5,000 to 6,000	6,000 to 7,000	7,000 to 8,500
Exhaust steam.....	4,000 to 5,000	5,000 to 6,000	6,000 to 7,000
Exhaust to condenser.			6,000 to 6,500

Engines whose design factor lies between 0.7 and 0.6 can have the following steam speeds:

Main steam pipe.....	6,500 to 7,500 feet per minute.
Throttle valve.....	5,500 to 6,500 feet per minute.

	High-pressure Ports.	Medium-pressure Ports.	Low-pressure Ports.
Entering steam.....	6,000 to 8,000	7,500 to 10,000	9,000 to 13,000
Exhaust steam.....	5,000 to 6,000	6,500 to 8,000	8,000 to 10,000
Exhaust to condenser			7,000 to 9,000

It is best to select the speed of exhaust steam, and from this get the necessary area of ports by means of the formula:

$$a = \frac{A \times PS}{\text{speed of exhaust}}, \qquad (47)$$

where A = area of cylinder;
PS = piston speed.

The breadth of the port having been taken from 0.85 D to 0.95 D, and allowance having been made for the ribs, the width of port can be found. If this is from 0.65 E to 0.8 E, where E is the eccentricity selected, the valve can be single ported; if more than that, it will be best to make it double ported, and to decrease the breadth of port so that each port shall be from 0.65 E to 0.8 E. The speed of the entering steam cannot be selected arbitrarily, but will be determined by the maximum port opening obtained from the valve diagram.

Entering speed steam: exhaust speed:: maximum port opening: width of port.

If the speed of the entering steam does not come within the limits given, the eccentricity or the width of port should be changed.

The area of the pipe, if one is used, or of each pipe, if two are used, going from one cylinder to the next, should be intermediate between the area of the exhaust ports in one cylinder and the area of the ports at maximum port opening in the next cylinder.

When piston valves are used, the breadth of the steam passage does not have to be considered, as the steam is admitted around the circumference of the valve, and the passage can be so designed as to take care of any reasonable diameter of valve or valves. In the slide valve, allowance has to be made for two or three ribs in the passageway; so, in the piston valve, the entire circumference of the valve is not clear opening. Bridges have to be carried across, to prevent the rings of the piston valve from springing out into the passageway, and these bridges usually take up about a quarter of the circumference. Allowing for this, the diameter of the piston valve can be obtained from the formula:

$$d = \frac{D^2 \times PS \times c}{V \times W}, \qquad (48)$$

where D = the diameter of the cylinder in inches;
PS = the piston speed of the engine in feet per minute;
V = the velocity of the exhaust in feet per minute;
W = the width of the port in inches;
c = 0.333 for 0.75 of the circumference clear opening;
0.357 for 0.7 of the circumference clear opening;
and 0.312 for 0.8 of the circumference clear opening.

The lead upon one end of the valve must be assumed before the valve diagram can be started. The lead upon the top end of the cylinder is generally made about $\frac{E}{6}$, and the difference in the cut-offs is so chosen that the lead upon the bottom shall be $\frac{1}{8}$ inch more. Both leads cannot be assumed if the cut-off positions are assumed; one lead can be assumed and the other worked out.

The eccentricity gives us the radius of the circle $ABCD$, Fig. 45. After drawing the two axes AB and CD at right angles, an arc can be struck from A with a radius equal to the assumed lead at the top. The cut-offs which were calculated for the cylinders at the very first are the mean cut-offs of the two ends of the cylinders. Equality of cut-off in percent of the stroke is never attempted in marine engines, where the ratio of connecting rod, length to length of crank, is so small that an impractical inequality of lead would result.

The cut-off on the down stroke is usually 7 or 8 percent greater than the cut-off on the up stroke. The excess of lead upon the bottom should be sufficient to allow for the greater forces to be overcome, and for the fact that, as wear takes place in the joints of the valve gear, the valve is going to drop down, and cause the lead upon the bottom to decrease.

The desired difference in lead can be obtained by laying off from the top end of the diagram a percentage of the diameter of the valve circle AF, equal to the desired mean percentage of the cut-off. A perpendicular dropped from the point F upon the valve circle will give a point through which a diameter GH can be drawn, that will give the cut-off position

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of the cranks upon the down and up strokes, which will be accompanied by equal leads. The desired inequality of lead, 1/8 inch, can be obtained by laying back 1/16 inch from *G* to *J*, and forward 1/16 inch from *H* to *K*, for the position of cut-off to give unequal leads. Draw from *J* a tangent to the lead arc at *A*. Bisect the line *JL* by a diameter *MN* of the circle. Upon this diameter draw the two eccentric circles *MO* and *NO*. Draw the lap circles *PQR* and *STU*. The angle *MOC*

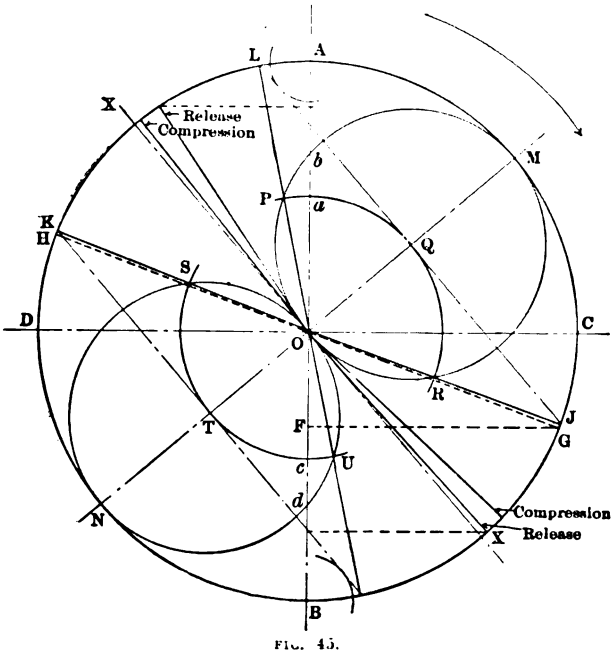

FIG. 45.

is the angle of advance, *MQ* is the maximum port opening at the top of the cylinder, and *TN* at the bottom. *OQ* is the steam lap for the top end of the valve, and *OT* for the bottom end.

No fixed rule can be given for finding the exhaust laps for the valve. Usually the release occurs from 7 to 15 percent before the end of the stroke, being earlier in fast running engines. The release upon the two ends can be made to occur at the same percent before the end of the stroke, but it is better to have the release upon the up stroke occur a little later than that upon the down stroke, as the dropping of the valve, due to wear, will cause it to occur gradually earlier upon the up stroke and later upon the down stroke. The compression due to this exhaust lap must be considered also, and if it occurs too early in the stroke, so that the engine would run badly, the release must be put earlier, to give a reasonable compression. This is especially important if the cut-off is somewhat short, in which case a rather large negative exhaust lap is required upon one end.

The best method of determining the amount of exhaust lap, and whether it is positive or negative, is to draw the line *XX* perpendicular to *MN*, and note the position of the release points relative to this line, which gives the position of the crank for the midposition of the valve. If the release on the down stroke occurs before the crank reaches *XX*, the exhaust lap is negative, if after the midposition it is positive.

The amount of lap will be the perpendicular distance between the release position and *XX*. Usually the exhaust lap upon the top is from —1/8 inch to —3/8 inch, and upon the bottom from 1/2 inch to —1/8 inch. There is no harm done if both laps are negative, thus permitting the two ends of the cylinder to be in communication at times, and no effect upon the indicator cards will be noticed until the sum of the exhaust lap amounts to about —1/2 inch. The distances *ab* and *cd* are also equal to the leads. It is well to tabulate the results, as shown later on in Table VIII.

If steam is taken at the middle rather than at the ends of the valve, the calculations are no different, the angle of advance of the eccentrics is increased by 180 degrees when they are placed upon the shafts, and the steam laps are placed nearer to the middle of the valve, instead of upon the ends.

The maximum port opening having been determined, and the width of port having been adjusted to give reasonable steam speeds, the final breadth of port in the case of the slide valve, or diameter of valve in the case of the piston valve, can be determined.

When piston valves are used, the high-pressure cylinder has one valve, the medium-pressure one or two, depending upon the size of the valves, and the low-pressure two or four valves. Two smaller valves are used in place of one valve when the one is more than half the diameter of the cylinder, or when the engine can be shortened materially by putting two smaller valves on either side of the center line, rather than one large one on the center line. When two valves are substituted for one, the diameter of each is half the diameter of the one for which they are substituted, as the steam is admitted around the circumference of the valves, and the circumference varies as the diameter.

The valves must be so located that their covers will not foul each other or the cylinder covers, and their location must also suit the crank shaft, in order that the ahead eccentric may be placed in the plane of the center line of the valve or valves. The distance between the center lines of the valves, when two

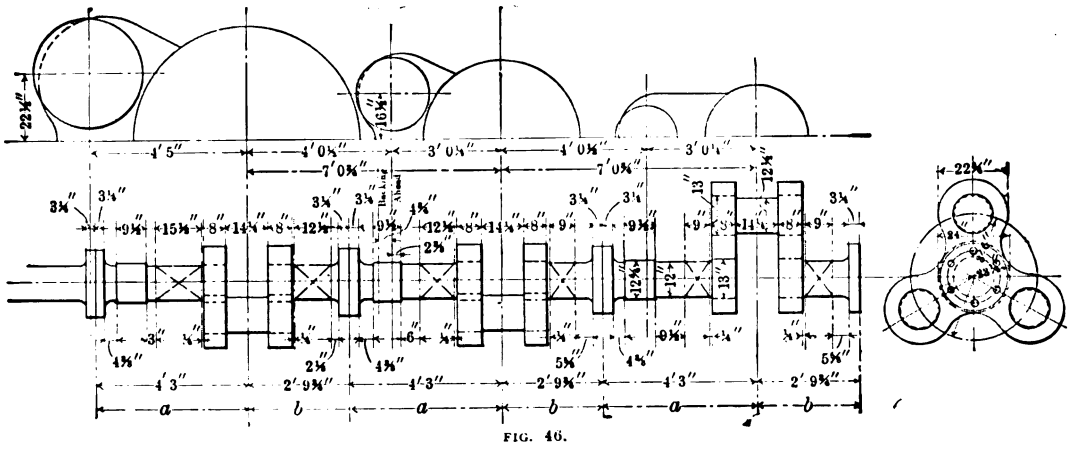

FIG. 46.

valves are used for one cylinder, should be not less than $y = 1.6\ V + 1$ inch, nor more than $y = 1.8\ V + 2\frac{1}{2}$ inches, where V = the diameter of the piston valves. The distance between the center line of the cylinder and the center line of the valves can be calculated, when the distance between valve centers has been selected, by letting this latter distance be one side of a right triangle, of which the hypotenuse is the sum of the radii of the cylinder cover and valve chest cover plus

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the desired clearance between the edges of the covers. This clearance varies from nothing to 6 inches, being determined sometimes by the arrangement of crank shaft.

$$X = \sqrt{\left(\frac{b}{2} + \frac{c}{2} + d\right)^2 - a^2}, \qquad (49)$$

where X = distance between center line of valves and cylinder, measured parallel to the center line of the engine;
b = diameter of cylinder cover;
c = diameter of valve chest cover;
d = clearance between covers;
and a = distance between center lines of valves.

The distance d should be sufficient to allow the steam passage between the barrel of the cylinder and the wall of the valve chest to be of the required area, without the passage being made too broad.

The accurate location of the center lines of the cylinders involves the finding of the diameters of the outside of cylinder covers and valve chest covers. Referring back to where the size of bolts used in the cylinder covers was determined, formula (18) gives the diameter of the inner surface of the barrel where the cylinder cover fits, and the diameter of the pitch circle of the bolts is taken as $C + 3d$, where C is the diameter referred to above, and d is the diameter of the studs used in the cover. The flange should extend beyond the pitch circle, an amount equal to $1\frac{1}{2}\ d$, so that the diameter of the outside of the cylinder cover should be:

$$E = D + 2L + 2J + 6d, \qquad (50)$$

where E = the diameter of the outside of the cylinder cover,
D = the diameter of the cylinder;
L = the thickness of the liner;
J = the thickness of the jacket space;
and d = the diameter of the cover stud.

The cover for the piston valve chest must be large enough to permit the liner to be put in. The diameter A having been determined by formula (48), and the thickness of the valve liner T being known, the diameter of the opening under the cover will be $A + 2T + \frac{1}{2}$ inch. The cover studs are usually 1 inch or $1\frac{1}{8}$ inches in diameter, with the same spacing as recommended for the cylinder cover studs, and the joint is usually $3d$ broad. The outside of the valve chest cover will then be:

$$F = A + 2 \times T + S \qquad (51)$$

where F = the outside diameter of the valve chest cover;
A = the diameter of the valve;
T = the thickness of the liner;
and S = $6\frac{1}{2}$ inches or $7\frac{1}{4}$ inches, depending upon whether 1-inch or $1\frac{1}{8}$-inch studs are used.

With these diameters, and the details and clearances of the shafting, a sketch like Fig. 46 can be made, locating the center lines of the cylinders and valves. The question as to whether or not the sections of the crank shaft are to be interchangeable must be decided before the distance between the center lines of the cylinders can be determined. If the sections are to be interchangeable, then the dimensions a and b (Fig. 46) must be the same on all sections, and the distances between the cylinder centers will be all the same, and equal to $a + b$. If the eccentrics for the low-pressure cylinder are to be on the low-pressure section of the crank shaft, then the minimum values of a and b will be determined by the low-pressure cylinder. If the eccentrics are to be on the thrust shaft or on the coupling, as shown in Fig. 46, then the minimum value of a will be determined by the medium-pressure cylinder, care being taken that a is not made so small that there is not room for the eccentric pad which must be provided for upon the

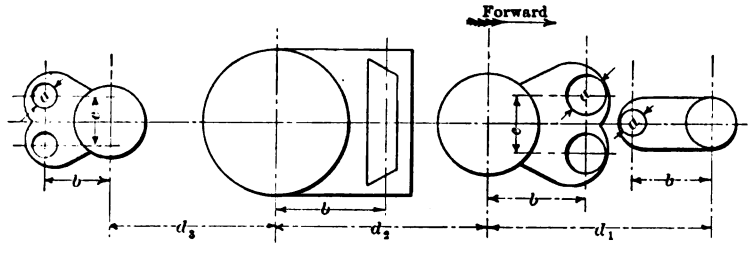

FIG. 47.—ARRANGEMENT KNOWN AS HAP-COD-LOS-MAD.

H—High-pressure cylinder.
M—First intermediate cylinder.
C—Second intermediate cylinder.
L—Low-pressure cylinder.
O—Valve is placed forward of cylinder.
A—Valve is placed aft of cylinder.
S—Cylinder has slide valve.
P—Cylinder has piston valve.
D—Cylinder has twin piston valves.
Y—Cylinder has four piston valves.

Number.	I. H. P.	R. P. M.	Boiler Pressure.	Cylinder Diameters.	Stroke.	Sequence of Cylinders, Type and Location of Valves.	First Cylinder. a.	First Cylinder. b.
41	600	220	200	8 -13½-22	18	HOP-MOP-LOD	44″	14″
42	1,100	140	...	17 -25 -43	30	HOP-MOP-LOS	8″	22″
43	1,500	80	175	22 -36 -59	42	HOP-MOP-LOS	10″	2′ 6″
44	1,500	85	200	19 -31 -54	42	HAP-MOD-LOD	8″	2′ 5″
45	2,250	100	160	23½-39 -65	42	HOP-MOS-LOS	10″	2′ 6½″
46	2,800	75	190	27 -44 -74	51	HOP-MOP-LAD	13″	2′ 11½″
47	3,750	100	165	28 -46 -76	48	HAP-MOD-LOD	16″	3′ 0½″
48	.....	...	...	19-28½-41-60	42	HAP-MOD-LOD-COD	8″	2′ 8″
49	4,000	100	165	32-52-(2)60	42	HAP-MOD-LOD-LAD	18″	3′ 3½″
50	.....	100	215	23-33½-48½-70	51	HAP-MOD-COD-LOS	15″	2′ 11″
51	5,000	85	170	32½-54 -89½	54	HAP-MOD-LOD	20″	3′ 9″
52	7,500	120	200	38½-59 -92	42	HAP-MOD-LY	16″	3′ 7″
53	8,000	86	200	35-50-70-100	66	HOP-LY-CAD-MAD	20″	3′ 9″
54	10,000	85	175	42-66½-(2)77	60	HAP-MAD-LAD-LAD	30″	4′ 10″

Number.	d_1.	Second Cylinder. a.	Second Cylinder. b.	Second Cylinder. c.	d_2.	Third Cylinder. a.	Third Cylinder. b.	Third Cylinder. c.	d_3.	Fourth Cylinder. a.	Fourth Cylinder. b.	Fourth Cylinder. c.
41	2′ 4½″	6½″	15½″	.....	2′ 11″	7½″	18½″	13″	.....	.....	.....	.....
42	3′ 9½″	9½″	23½″	.....	4′ 10″	.....	2′ 10″	.....	.....	.....	.....	.....
43	6′ 4½″	17″	3′ 4″	.....	6′ 4½″	.....	3′ 8″	.....	.....	.....	.....	.....
44	6′ 10″	8″	2′ 5″	17″	6′ 10″	16½″	4′ 1″	26″	.....	.....	.....	.....
45	5′ 7½″	...	3′ 0½″	.....	7′ 4½″	.....	4′ 4″	.....	.....	.....	.....	.....
46	7′ 1″	25½″	3′ 9½″	.....	7′ 1″	25½″	4′ 7″	3′ 6″	.....	.....	.....	.....
47	8′ 0½″	18½″	3′ 2½″	2′ 6″	8′ 7″	33½″	4′ 11″	4′	.....	.....	.....	.....
48	7′	15″	2′ 9½″	.....	7′	19″	4′ 2″	2′ 4″	7′	12″	4′ 1½″	21″
49	.....	18″	3′ 5″	2′ 6″	.....	18″	3′ 8½″	2′ 6″	.....	18″	3′ 8½″	2′ 6″
50	8′ 4″	15″	2′ 11″	2′ 6″	7′ 7″	23″	3′ 7½″	3′	8′ 4″	...	4′ 0″	.....
51	10′ 2″	22″	3′ 9″	3′	10′ 2″	34″	5′ 11½″	4′ 6″	.....	.....	.....	.....
52	10′ 7″	20″	3′ 11″	3′ 1″	10′ 9″	20″	5′ 7″	2′ 8″	.....	.....	.....	.....
53	9′ 7″	25″	5′ 9½″	5′	10′ 2″	28″	4′ 10½″	4′ 6″	9′ 3″	17″	4′ 5″	2′ 9″
54	10′	30″	4′ 10″	4′ 9″	10′ 4″	36″	5′ 2″	5′	10′ 4″	36″	5′ 2″	5′

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low-pressure section, even though it is not used for that cylinder. Sometimes all eccentrics are placed on the couplings.

When the crank shaft sections are not made interchangeable, the engine can generally be made shorter. A good arrangement of cylinders and valves is to have the medium-pressure and low-pressure valves grouped together between those two cylinders, and the high-pressure valves between the high-pressure and medium-pressure cylinders. This makes the piping very compact, although the over-all length of the engine may not be any less than with the other arrangement.

In a four-cylinder engine all of the sections are not usually interchangeable; but the first two sections are interchangeable, and so are the last two sections.

Fig. 47 gives arrangement data for several engines. Such a table is convenient for checking calculated results, and for estimating the distance between cylinder and valve center lines when there is not time for calculations.

It is very often convenient to know the length, breadth and height of an engine approximately. It will be found that the length of the engine over-all is from 1.8 ΣD to 1.9 ΣD, when the sections of shafting are not made interchangeable, and from 1.9 ΣD to 2 ΣD when the sections are interchangeable. ΣD is the sum of the cylinder diameters. The height of the engine from the bottom of the bed to the top of the covers is from 5 to 5¼ times the stroke for naval engines, and from 5½ to 6 times the stroke for merchant engines. The breadth of the bed varies considerably, but is almost twice the low-pressure diameter in merchant engines, and from 1½ to 2 times the low-pressure diameter in naval engines, depending upon the type of framing.

THE STEAMER COMMONWEALTH.*

BY WARREN T. BERRY AND J. HOWLAND GARDNER.

The *Commonwealth* was built for night service between New York and Fall River, a run of 180 statute miles, making one stop of about half an hour at Newport. The maximum designed speed is 22 statute miles per hour, although the established schedule requires a speed of only 18 statute miles, and with fair tide and wind 16 statute miles are all that are necessary. A speed of 20 or 22 miles is often required to minimize delays caused by head tides, high winds, delays at terminals and fog detention.

* Read before the Society of Naval Architects and Marine Engineers, New York, Nov. 20, 1908.

Inquiry was made as to the advisability of installing the Parsons type of turbine, but the economical results appeared to be rather experimental for speeds varying between 16 and 22 miles per hour. Experience with propeller and side-wheel steamers, in this particular service, demonstrates that very much greater overhang of guard can be fitted to the side-wheel boat. On the *Commonwealth* 19 feet 8 inches overhang, each side of hull, was necessary to provide for the spacious saloons and staterooms demanded by the traveling public. This extreme breadth of guard is in addition a very efficient safeguard against serious damage to the hull in case of collision. The compound inclined engine with feathering wheels, as adopted, combines the ability to stop and back very quickly, utilizes only lower hold space, which is of very little value for freight or passenger accommodation, and avoids the excessive vibration common to screw propellers in shallow-draft vessels.

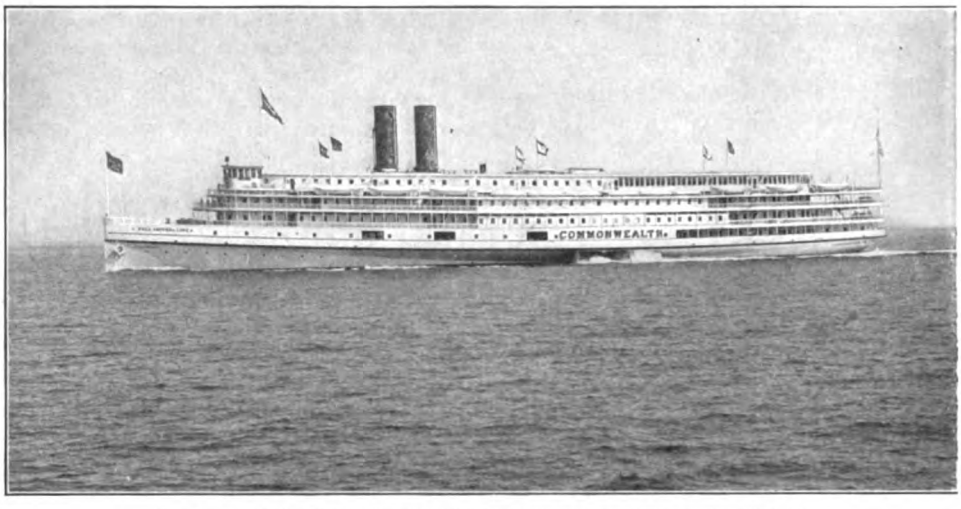

FIG. 1.—BROADSIDE VIEW OF THE FALL RIVER LINE STEAMER COMMONWEALTH.

The contract for building this steamer was made by the New England Navigation Company with the Quintard Iron Works Company on Oct. 12, 1906, the specified time of delivery July 1, 1908. The hull was launched at the yards of the William Cramp & Sons Ship & Engine Building Company Oct. 9, 1907, and the work of installing machinery and joiner work immediately commenced. The steamer was finally delivered, ready for service, with furniture and outfit complete, June 23, 1908. The general dimensions are as follows:

Length over all	455 feet 2 inches.
Length between perpendiculars	437 feet 11 inches.
Beam of hull molded	55 feet.
Beam over guards	94 feet 7 inches.
Molded depth, lowest point of sheer	22 feet.

TABLE OF WEIGHTS.

	Gross Tons.
Hull, ship carpenter work and steel construction	2,210
Joiner work	835
Steam engineering	1,760
Hull engineering	240
Coal	150
Water	40
Equipment, furniture and outfit	175
Total	5,410

Displacement, light (13 feet draft salt water), 5,410 gross tons.

Displacement, loaded (15 feet draft salt water), 6,410 gross tons.

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The hull is built on the bracket plate and longitudinal system of the general scantling shown on midship section, Fig. 7. Seven watertight bulkheads extend to the main deck without doors or other openings, dividing the hull into eight watertight compartments above the double bottom. The double bottom extends for a length of 335 feet, and the margin plate is 5 feet above the base line. This double bottom is divided into forty-six watertight compartments.

To obtain quick handling in the harbors of Newport and New York, a rudder 14 feet 8 inches long, 12 feet 6 inches deep, is installed. This rudder is operated by a 26-inch diameter by 16-inch stroke Sickles type steering engine, located in the forward hold, connected by wire cables 1⅝ inches diameter to a circular steering head. This steering head is fastened to the rudder stock at the center and nigger-head at the aft end of the rudder, in order to distribute the stresses on the rudder and do away with the use of aft quarter blocks. The stock is utilized as a steadiment and for connection to a hand auxiliary gear of the diamond screw type, located on the saloon deck. A mechanical telegraph is fitted for communication from the pilot house, with direct reply from the rudder stock.

Two stockless anchors of 6,500 pounds each, with 180 fathoms of 2-inch stud link chain cable, are handled by a two-cylinder, 14-inch by 14-inch anchor windlass, with a capstan attachment on the saloon deck and two capstan heads on the main deck. For warping the steamer into dock two 12-inch by 14-inch steam capstans are located on the aft quarters.

The propelling machinery, designed for a maximum indicated horsepower of 10,000, is composed of a double compound, inclined, reciprocating engine with two high-pressure cylinders, 50 inches diameter and two low-pressure cylinders 96 inches diameter, with a common piston stroke of 114 inches, connected to two pairs of cranks set at right angles, shrunk on hollow forged steel shafts. The shaft is in three sections: two outboard or wheel shafts and one center shaft, all 27 inches diameter at the main journals and 30 inches diameter at the gunwale bearings. The crank pins are 22 inches diameter, shrunk in cranks on outboard shafts, but arranged

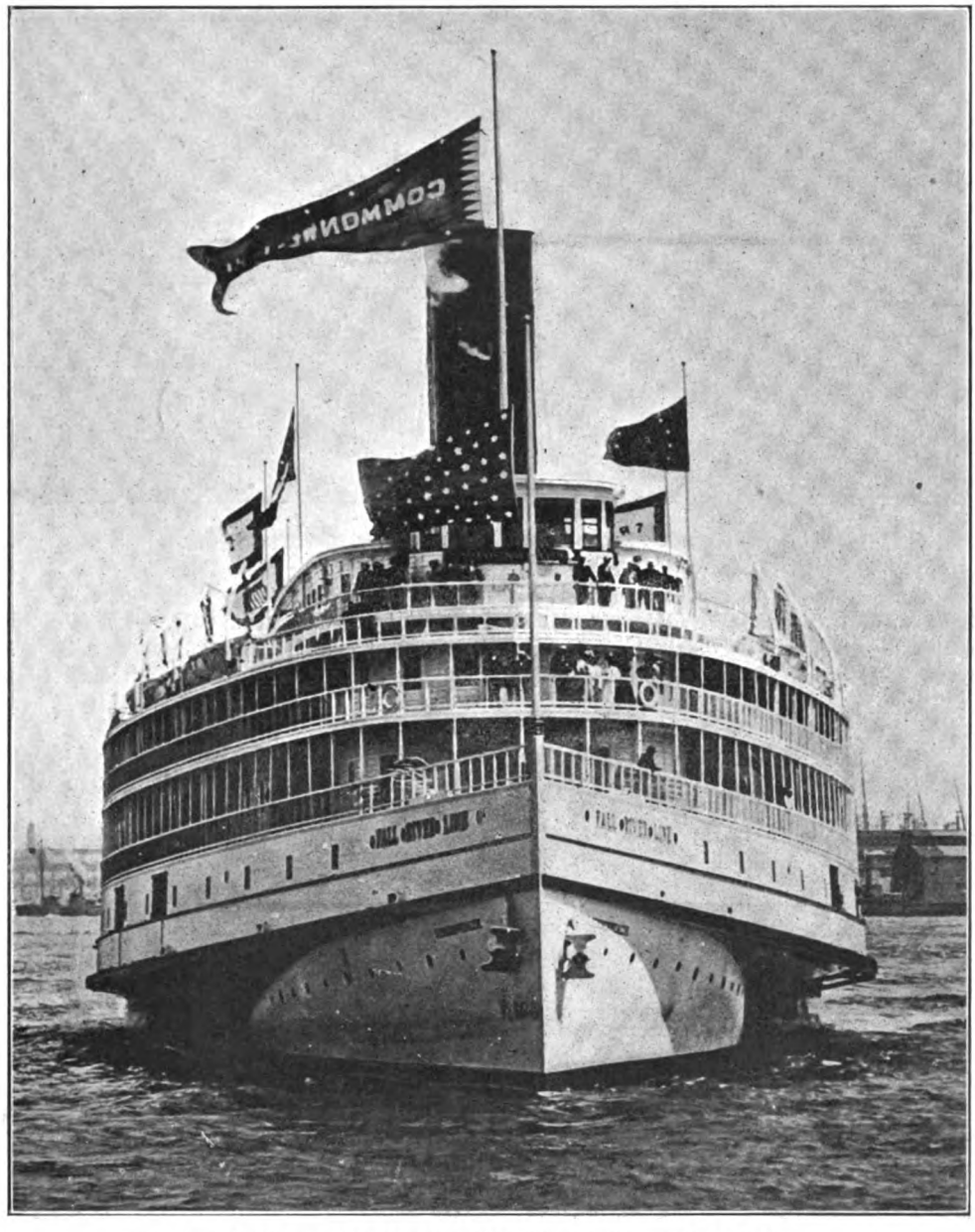

FIG. 2.—BOW VIEW OF THE NEW FALL RIVER LINE STEAMER COMMONWEALTH.

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FIG. 3.—THE GENERAL ASSEMBLY ROOM, OR LOUNGE, ON THE COMMONWEALTH.

with loose brass chocks in the inboard cranks to provide for any change of alinement. All cylinders are fitted with double poppet valves, Sickles adjustable cut-off on the high-pressure cylinders, and Stevens fixed cut-off on the low-pressure cylinders, all operated with Stephenson links controlled by a 20-inch by 24-inch steam reversing engine. Two surface condensers of cylindrical type, each containing 8,000 square feet cooling surface, are located outboard of the low-pressure

FIG. 4.—THE DINING SALOON ON THE COMMONWEALTH.

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cylinders, with suction pipes to two vertical air pumps 5 feet diameter by 30-inch stroke connected to the low-pressure crossheads. The engine frame is built of steel plates and angles in the form of box girders, so arranged that the main bearings are entirely within the frame.

The wheels are of the feathering type, of the following dimensions:

Diameter at center of trunnions.....	26 feet 9 inches.
Diameter outside of buckets.....	31 feet.
Diameter outside outer rim.....	33 feet.
Number of arms.....	12
Width of buckets.....	5 feet.
Length of buckets.....	14 feet 6 inches.
Thickness of buckets.....	1 inch.
Thickness of bucket reinforcing plates.	⅞ inch.
Curve of buckets.....	9 feet 6-inch radius.
Diameter of main pins.....	8¼ inches.
Diameter of rocker arm pins.....	6 inches.

The centers are of cast iron, the arms of wrought iron, to which are bolted cast steel trunnions, the buckets of marine steel with brackets and rocker arms of cast steel and pins of wrought iron cased with brass working in one piece lignum-vitæ bushings.

Steam is supplied by ten Scotch boilers, located five on each side, with center fire-room extending fore and aft. The boilers are 15 feet 6 inches in diameter by 13 feet 6 inches long, each having three Morison furnaces, 50 inches inside diameter, with a total grate surface of 937 square feet and a total heating surface of 29,340 square feet. Forced draft is supplied to closed ash pits by four blowers; two of these blowers are 7 feet in diameter by 32-inch face, driven by direct-connected engines, 7 inches diameter by 10½-inch stroke, and two blowers 8 feet in diameter by 38-inch face, driven by direct-connected engines, 10 inches diameter by 12-inch stroke. The discharge from two blowers located in the forward compartment is led over the main deck at the forward fire-room bulkhead, and the suction ducts for aft blowers lead from engine room over the main deck at the aft fire-room bulkhead, leaving the bulkheads watertight. Blower ducts are so arranged that they ventilate the engine room, boiler room and forward cabins as well as furnishing air for forced draft. A vertical fire-tube donkey boiler, 7 feet 2 inches diameter, 12 feet 5 inches high, is located on the main deck.

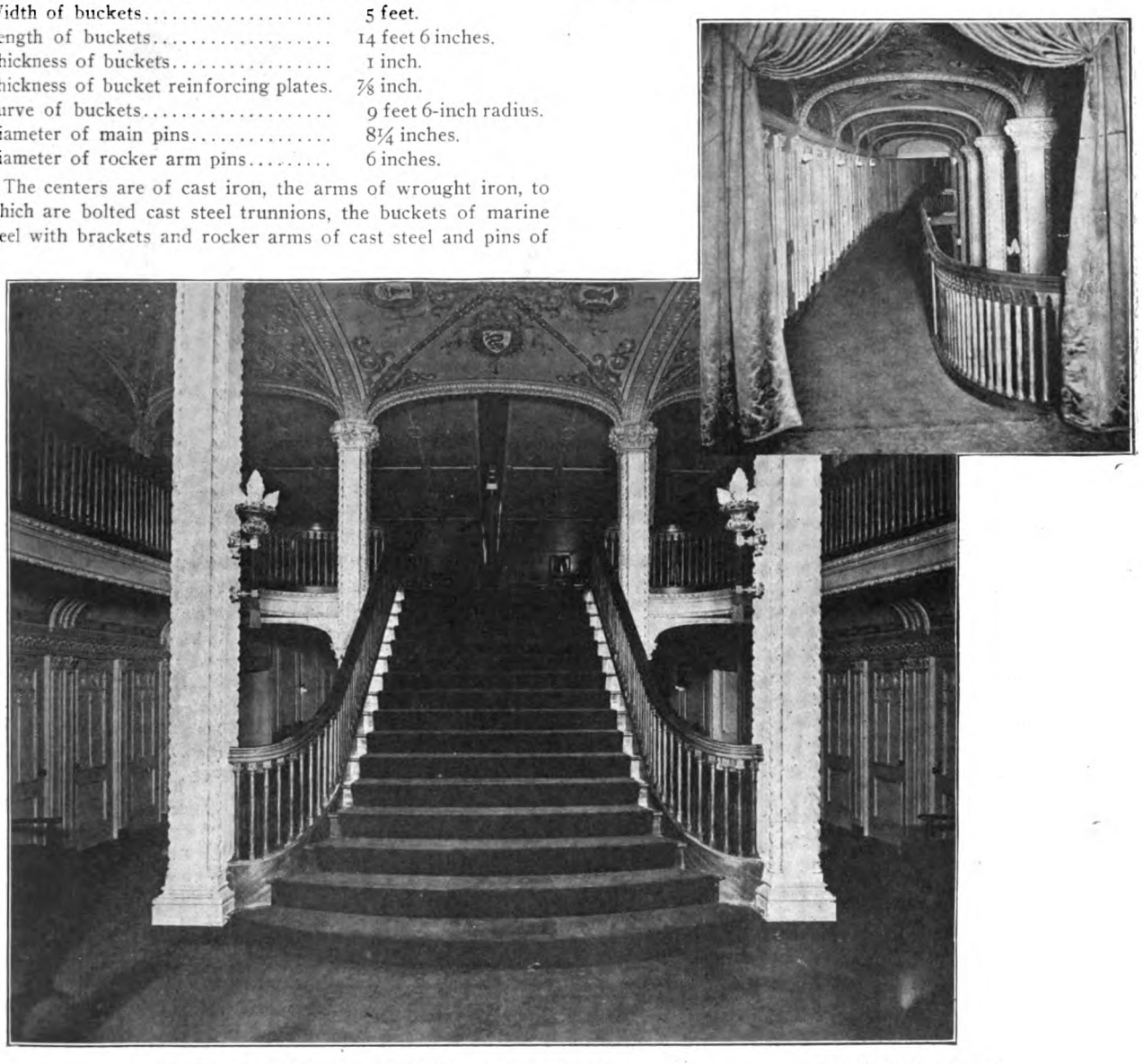

FIG. 5.—ONE OF THE BROAD STAIRWAYS IN THE MAIN HALL. AN UPPER-DECK CORRIDOR.

The following pumps complete the engine installation:

Four centrifugal circulating pumps, 12-inch suctions.

Two boiler-feed pumps, outside packed plunger, duplex, 14 inches by 9 inches by 18 inches.

Two fire and sanitary pumps, also connected to boiler-feed lines. All brass water ends, duplex, 18½ inches by 12 inches by 12 inches.

One sprinkler pump. All brass water ends, duplex, 16 inches by 12 inches by 12 inches.

One bilge pump, duplex, 10 inches by 8½ inches by 12 inches.

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One fresh water sanitary pump, duplex, 6 inches by 6 inches by 12 inches.

One donkey feed pump, single, 6 inches by 3¾ inches by 7 inches.

Two injectors for boiler feed.

Two 8-inch diameter by 15-inch stroke bilge pumps operated from main engine.

The electric outfit is comprised of two 75-kilowatt generators with 10½-inch by 18-inch by 8-inch engines, and one 50-kilowatt generator with engine 9½ inches by 15 inches by 6 inches, located in the engine room on the main deck, about 3,000 incandescent lights distributed throughout the vessel, a 24-inch searchlight on top of the pilot-house with pilot-house control, an electric elevator with a capacity of 2,000 pounds, running from the main deck to the store room and kitchen on the dome deck, and two electric blowers located in the after hold for the ventilation of the aft cabins. All wiring in the engine and boiler compartments, cargo space, emigrant quarters, crew quarters, kitchen and pantries, together with all outsire wiring, is in conduit with steam-tight fixtures, and all concealed wiring throughout the steamer is also run in conduit.

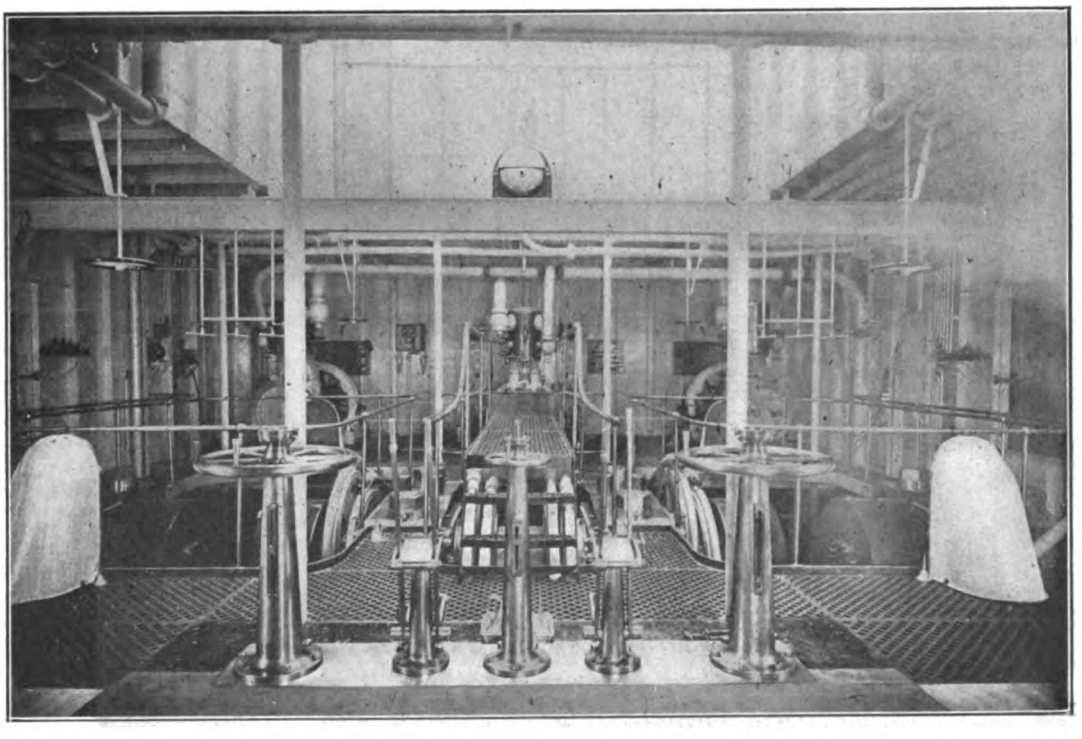

FIG. 6.—THE STARTING PLATFORM IN THE ENGINE ROOM OF THE COMMONWEALTH.

Particular attention has been paid to fire protection and fire-fighting. appliances. All wood work throughout the cargo space, emigrant quarters, crew's quarters on the main deck, and kitchen on the dome deck, is covered with galvanized iron, fastened directly to the wood. Steel decks are fitted over the boiler compartment, coal bunkers and engine compartment. The engine room and boiler room ventilators and enclosures are of steel, extending through the top of the dome. Two fire bulkheads are provided, extending from the main deck through all decks to the dome, dividing the vessel into three fire compartments. These bulkheads are of double thickness ⅞-inch tongue and grooved wood, cross-planked diagonally and lined on both sides with Sackett plaster wall board covered with galvanized iron. Suitable sliding doors are provided in the main corridors and freight space. An iron bulkhead extending entirely across the upper deck house is fitted just forward of the kitchen range.

There are sixty fire hydrants located throughout the steamer, connected by copper fire mains with the fire and wrecking pumps, a 50-foot length of hose is coupled to each hydrant, and the location is such that all portions of the steamer are protected. Portable hose is also carried by both engine and deck departments, and thirty-seven fire extinguishers are located in convenient places.

In addition to this an independent sprinkler system is provided, with 1,800 automatic Grinnell heads distributed throughout the interior of the steamer, staterooms and lockers, not exceeding 8 feet from center to center in any place. This system is divided into thirty circuits, each with a 4-inch diameter main from a manifold located in the engine room on the main deck. To this manifold the main discharge from a 16-inch by 12-inch by 12-inch duplex sprinkler pump is connected. This pump at all times maintains a pressure at the manifold of 100 pounds per square inch, and is fitted with a governor to maintain this pressure in case of the opening of any of the circuits and sprinklers, and is also fitted with a throttle by-pass, which can be operated from the main engine room.

Supplementary to this system is a thermostat system with mercury thermostats, located not over 12 feet centers with all wires run in conduit, and divided into circuits corresponding with the sprinkler circuits. This system terminates at two annunciators, one in the main saloon and one in the engine room indicating the circuit number. The opening of a valve of corresponding number on the sprinkler system manifold supplies water to the sprinklers at the fire. In addition to the two main annunciators on the thermostat system, small annunciators are located throughout the saloons to determine the location of a fire within a range of a few staterooms. All the annunciator drops, besides showing the circuit number, indicate the location on the steamer, and ring 8-inch alarm bells located in the crew's quarters, engine room and saloons. This system deviates to some extent from the systems in use on land. The wet-pipe system, where all the pipes are filled with water under pressure, was impossible, because of the great weight and danger of freezing. The dry-pipe system

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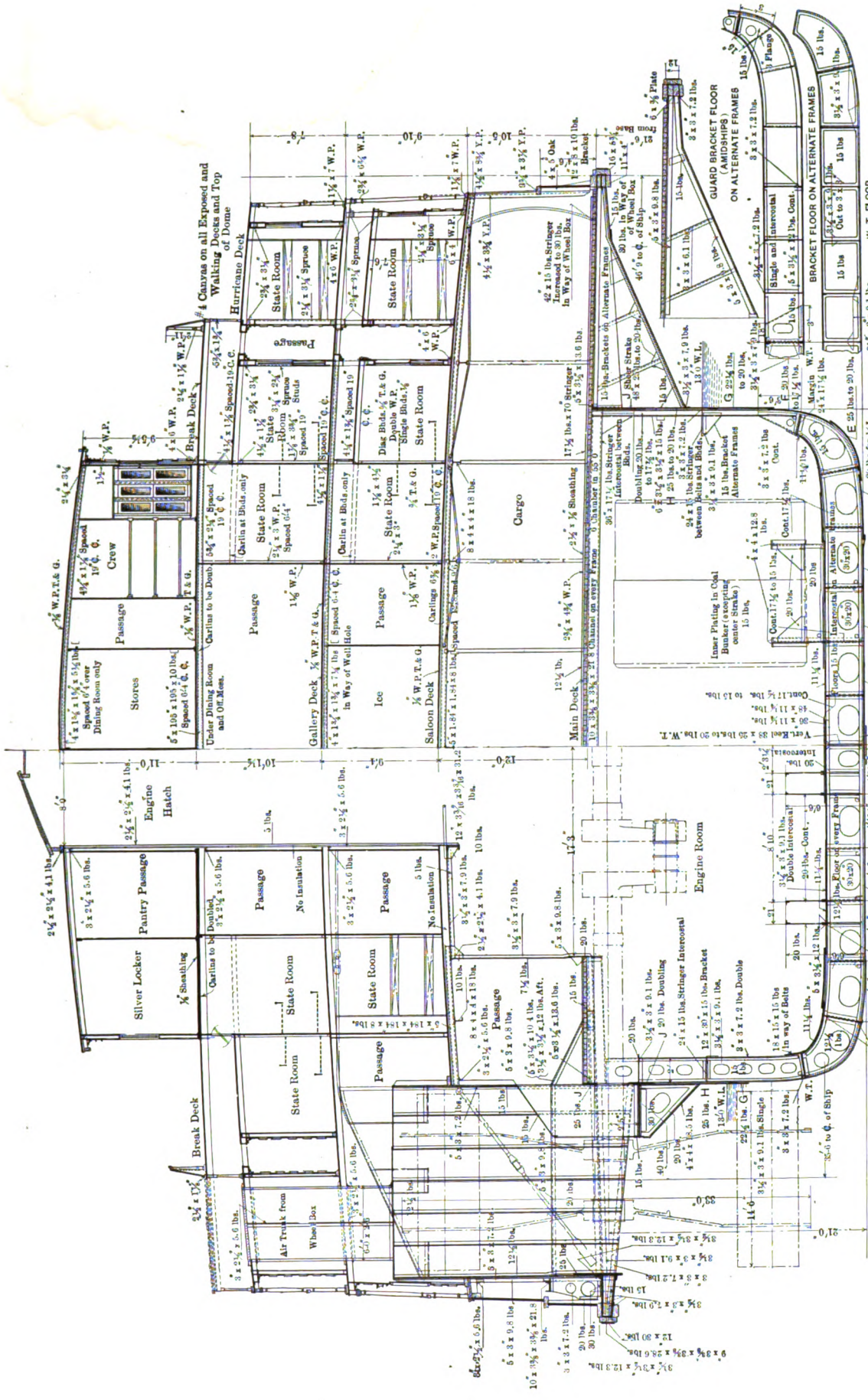

FIG. 7.—MIDSHIP SECTION AND SECTION THROUGH THE BOILER SPACE OF THE COMMONWEALTH.

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with pipes filled with air under pressure which, when released, operates an automatic valve admitting water to the system, was not used because of the possibility of flooding a section of the ship where the pipes might be damaged in case of collision. A watchman's time detector is connected with thirty-eight recording stations, so located that in order to make a proper record, the watchman must pass through every section of the ship.

An 8-inch wrecking suction pipe is run fore and aft under the main deck. This is connected by 8-inch valves and suction lines to each compartment above the double bottom. The valves are so located in the compartments that they can be operated from the main deck. This system is connected to the two 18½-inch by 12-inch by 12-inch pumps on the main deck. The 10-inch by 8½-inch by 12-inch bilge pump, located in the engine compartment, has an independent suction line to each compartment above the double bottom and a connection to each of the forty-six watertight compartments in the double bottom. The four 12-inch circulating pumps are each fitted with 12-inch bilge suctions.

Twelve metallic lifeboats, ten 26 feet by 7 feet by 2 feet 9 inches deep, and two 26 feet by 6 feet 8 inches by 2 feet 9 inches deep; twelve life rafts, six 20 feet by 6 feet 8 inches, and six 18 feet by 6 feet 8 inches by 2 feet 3 inches deep; 2,250 block cork life preservers distributed throughout the staterooms, crew's quarters and saloons, and a Lyle gun complete the life-saving equipment.

A standard long-distance telephone is located in every stateroom and at various places throughout the saloons and crew's quarters, all intercommunicating through a switchboard. Independent telephones are fitted between the pilot-house and engine room and pilot-house and wireless telegraph room.

The location of the passenger toilet rooms between the engine and boiler enclosures, entirely away from ventilation through outside windows, as usually installed, utilizing a portion of the steamer that is undesirable for staterooms, is a departure which the result in use has justified. Large ventilators extend from the toilet rooms to the upper deck, one ventilator immediately back of the kitchen range and the other against the iron engine-room enclosure. The heat from the range and engine-room enclosure creates a draft through these ventilators, affording perfect ventilation. In addition suction pipes are connected to each urinal and toilet bowl extending to siphon hoods on the upper deck.

The officers' and crew's quarters are located mainly on the dome deck forward of the dining room and kitchen, though the deck hands and firemen are located below the main deck forward. On the dome deck is located the officers' mess room, seating forty-six, thirty officers' staterooms, with three water closets and two shower bath rooms for crew.

The kitchen and pantries are located between and around the boiler and engine enclosures on the dome deck. All wood work in the kitchen is lined entirely with galvanized iron and the floors covered with sheet lead and tile set in Sarco cement. The kitchen is fitted with a sectional range 21 feet 6 inches long, with six ovens and six fires, four broilers, each 2 feet 6 inches long, an electrically-driven dish-washing machine with electric hoist, two electric toasters, urns for tea, coffee and milk, and the usual hotel outfit of ice boxes, warming tables, bain marie, etc. The ice boxes, kitchen and pantries with silver and glass lockers, comprise about 2,400 square feet of deck space.

Because of the great weight involved, the butcher shop, with its ice boxes, is located on the main deck, convenient to the electric elevator.

A steam-heating system is provided of sufficient capacity to comfortably heat the vessel in the coldest weather, the main saloons, parlor staterooms and crew's quarters are fitted with standard radiators, while the regular passenger staterooms are heated with sill radiators divided into sections of about ten staterooms each, all arranged with independent cut-outs and to drain through traps to the main condensers.

The sanitary system provides fresh water under pressure to kitchen, pantries and bath rooms, and salt water to toilets, which are fitted with flushometers, porcelain bowls and ample drainage.

In general the decks above the main deck are of ⅞-inch tongue and grooved pine nailed to pine carlins of the scantling shown, all spaced 19-inch centers, stiffened by a steel structure comprised of channel beams, 12 feet 8-inch centers, riveted to 8-inch I-beam steel girders, extending fore and aft under stateroom bulkheads, supported by iron pipe stanchions riveted at top and bottom, or wood stanchions with ⅝-inch iron rods extending from deck to deck, rods spaced 12 feet 8-inch centers, and wherever possible these rods pass through and are nutted under the iron beams. All saloon deck girders are so situated that these rods pass through and are secured to the top flange. The bulkheads between staterooms are of tongue and grooved pine, alternately ⅞ inch single thickness and ⅝ inch double thickness, planked diagonally, nailed through with clinched nails. The double bulkheads are located at the iron carlins and fastened to them to obtain necessary athwartship rigidity.

The general arrangement of staterooms provides three rows of staterooms on each side of the saloon and gallery decks. The staterooms opening from the saloons are ventilated by concealed openings to the saloon and transoms opening over the upper deck of the adjoining outside rooms, the height of which is reduced for this purpose. The outer rows of staterooms have windows opening on the passageway and the outside of the deck house, respectively.

There are in all: eight staterooms for crew, containing 192 berths; forty-one staterooms for officers, containing 111 berths; 420 selling rooms for passengers, containing 826 berths; forty-five free berth rooms, containing 460 berths.

On the main deck forward are accommodations for thirty-six women and seventy-eight men emigrants. These quarters are fitted with galvanized iron pipe berths with canvas bottoms and hair mattresses. There are 300 spare mattresses for the use of passengers in the saloons, making a total of 2,003 mattresses.

The location of the dining room on the upper deck, with its attendant weight, necessitated a departure from the usual construction in steamers of this class. In order to support this weight, I-beam girders were run under this deck, and the entire structure supported by stanchions extending through the main saloon. In order to furnish a base for decorative treatment, double groined arches were fitted between these stanchions.

The lobby, or quarter deck, is treated in modern English, with oak and marquetrie panels. Adjoining the quarter deck are the purser's office, bar-room, barber shop, coat room and toilets. Aft is the library or social hall, finished in cream and gold, in the period of Louis XVI., and aft of this library is the woman's cabin, where are located the free berths for women passengers. From the quarter deck the main stairway leads up to a saloon finished in the period of Louis XV. Forward of this is the grand saloon with groined ceiling. This room has been treated in the Venetian-Gothic type of architecture, with decorated panels in all the arches and artistically painted lunettes at the sides. At the forward end is a large mural painting typifying the Commonwealth.

The passageways leading forward are of the period of Louis XVI. Opening off these passageways are toilet rooms, ice room, linen room, telephone and wireless telegraph rooms. Forward of this passage is the Empire saloon, which is finished in Honduras mahogany with gold ornamentations. From this saloon the forward staircase leads to the Louis XVI. saloon

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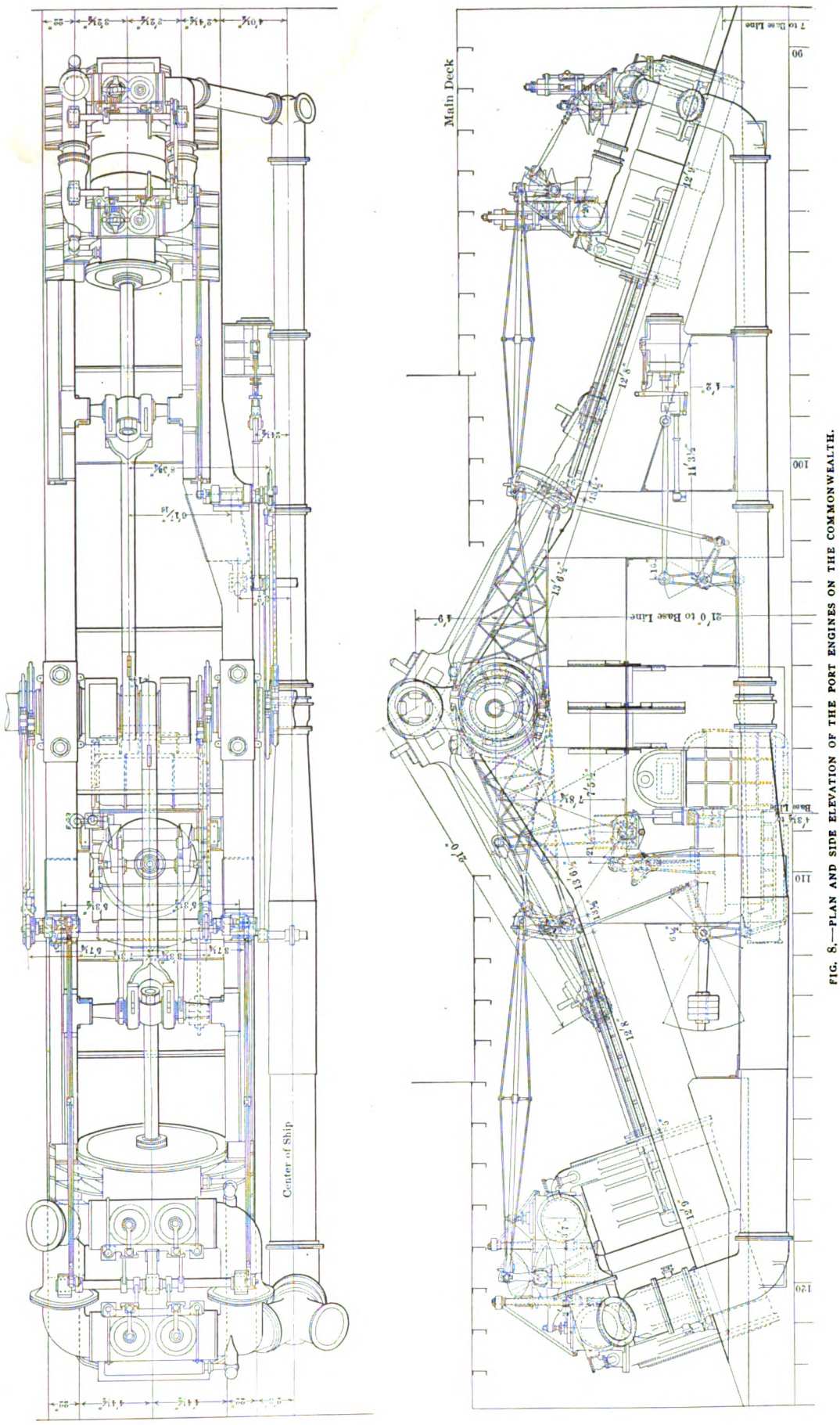

FIG. 8.—PLAN AND SIDE ELEVATION OF THE PORT ENGINES ON THE COMMONWEALTH.

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on the forward gallery deck. This saloon, with the passageways leading aft alongside of the engine enclosure, are decorated in gray and white of the period of Louis XVI. Adjoining these passages are the gallery toilet rooms and a large writing room and newsstand. Aft of the gallery section of the Venetian-Gothic saloon is the Adams saloon, finished in primavera, with hand-painted panels and frieze. From the Adams saloon are stairways to the dining room and café on the dome deck. The café is finished in gray, open grain chestnut, in the period of the Italian Renaissance, and has a seating

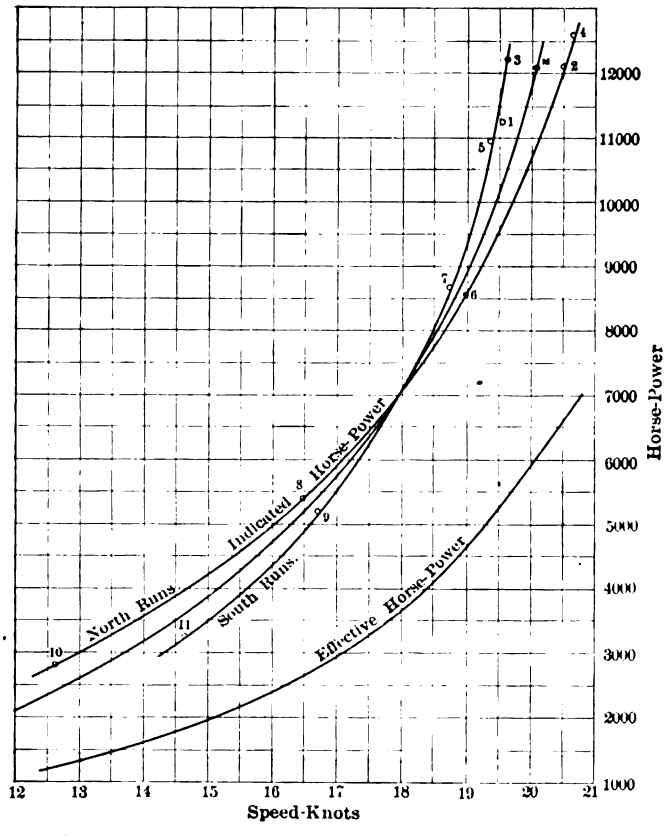

FIG. 9.—POWER AND SPEED CURVES FROM TRIALS OF THE COMMONWEALTH.

capacity of seventy-six. The floor is made watertight by covering the deck with canvas, painted, and then finished with interlocking rubber tiling. The tables and chairs are of polished oak, and the buffet bar at the forward end is of chestnut, to match the trim. The center of the room is lighted from a large dome with concealed lights.

The dining room has a seating capacity of 216, and is finished in gray and white in the period of Louis XVI. In the central portion of the ceiling are three domes, built of wire lath, covered with a special papier-mache plaster, the center one 24 feet 6 inches long and the two end domes 11 feet diameter. The center of the room is lighted from these domes by concealed lights. In addition each table is fitted with two-branch candelabra, and the sides of the room are lighted from bracket fixtures.

Off the Louis XV. and Adams saloon are located sixteen parlor bed rooms, four with bath rooms and two with shower bath rooms, fitted with the usual lavatories and toilet arrangements. These rooms are variously finished in the period of Louis XV. and Louis XVI.

In general, throughout the decorated portions of the steamer, all ceilings are made flush, the carlins being covered with composite board divided into suitable panels with decorated moldings. The groined arches of the Venetian-Gothic saloon are formed of narrow tongue grooved strips, covered with ¼-inch composite board, and finally the decoration applied on canvas. All the furniture, carpets, electric light fixtures and hangings are made in style to conform to the period of decoration of the saloon in which they are located.

Each stateroom is fitted with the usual two berths, bent wood stateroom chair and stool, mirror, electric light, glass and ice water pitcher rack. In the matter of washstands, however, a departure has been made in avoiding the use of wood. The lavatories are one-piece porcelain basins, fastened directly to the bulkhead, with waste into round porcelain slop jars supported by enameled iron brackets. Water is supplied from pitchers held in enameled iron racks. This arrangement of independent pitchers and slop jars was preferred to any fixed type on account of the facility with which they can be cleaned.

The *Commonwealth* has been in continuous service during the past summer, and has fulfilled all expectations of her owners, designers and builders.

PROGRESSIVE SPEED TRIALS.

The vessel was put into regular service immediately on completion, and on account of the large amount of travel she could not be spared for a trial trip until Nov. 14, at which time progressive speed trials were run over the Government course in Narragansett Bay, for the purpose of determining the indicated horsepower at various speeds and comparison with the data obtained from the model experiments at the Government tank at Washington. The model experiments were carried out on a draft corresponding to 13 feet mean, or 5,410 tons displacement salt water, trim 10 inches by the stern. The mean draft, during the trial on Nov. 14, determined by the observations before and after the runs, was 13 feet ½ inch, trim 12 inches by the stern, or 5,430 tons displacement.

The course is one knot long from marks on Jamestown Island, at the north end, to marks on Rose Island at the south end. The depth of water varies from 20 to 23 fathoms.

The steamer made her regular run from New York to Fall River, and after discharging passengers and freight, was taken down the bay to the course, where eleven runs were made, starting at about a quarter before eleven and ending at about half-past two. During the first runs the tide was flood, changing to ebb at about 12:45. Time over course, total revolutions of engine on the course, and steam pressures were recorded, and all cylinders indicated at the beginning and end of the run. These results were tabulated, and curves of speed and revolution, and speed and indicated horsepower plotted, and the mean curves drawn.

The first four runs were at 29.77 revolutions per minute; speed, 20.05 knots, or 23.09 statute miles per hour; indicated

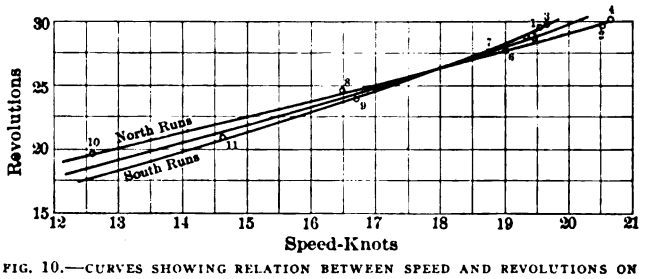

FIG. 10.—CURVES SHOWING RELATION BETWEEN SPEED AND REVOLUTIONS ON THE COMMONWEALTH.

horsepower 12,000. The corresponding effective horsepower from model tests was 5,950, which gives a propulsive coefficient of practically 50 percent. The apparent slip, figuring at the outside of buckets, was 29.92 percent, or practically 30 percent. It will be seen from the table that the propulsive coefficient varies between 50 and 52 percent, and the slip between 28 and 30 percent at the various speeds.

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It is interesting to note the range of power which is necessary for the particular service in which this vessel runs. For a speed of 16 statute miles per hour, the corresponding indicated horsepower is 3,100; for a speed of 22 statute miles per hour, the corresponding indicated horsepower is 9,050.

This speed trial was conducted under the regular running conditions of the steamer, as to coal, crew, oil, etc. The coal was the regular buckwheat size of the same quality regularly supplied. No difficulty was experienced in maintaining a constant steam pressure during the full-speed runs. In fact, on the first run over the course the steam pressure increased 3 pounds. This is the greatest variation in steam pressure on any of the runs. All runs were made with the throttle wide open, and variations of speed were obtained by the adjustable cut-off on the high-pressure cylinders. It may be noted that the last two runs were made with a steam pressure of 126 pounds, as it was impossible to obtain the desired low revolutions on these runs with the adjustable cut-offs with full boiler pressure without throttling the engine.

STEAMER "COMMONWEALTH." PROGRESSIVE SPEED TRIAL DATA

Run.	Direction.	Time.	Steam Pressure Engine Room Gage.	Average Revs. Per Min.	Average Revs. Per Min.	Speed Knots.	Speed Statute Miles.	App. Slip Outside of Buckets.	Indicated H. P.	Eff. H. P. From Model.	Prop. Coeff.
		Min. Sec.									
1	S.	3 4	145	29.51							
2	N.	2 55½	150 148	29.74							
3	S.	3 3	148 147	29.67	29.77	20.05	23.09	29.92%	12000	5950	50%
4	N.	2 54	148 147	30.17							
5	S.	3 54⅘	147 147	28.62							
6	N.	3 9²⁄₅	150 148	27.56							
7	S.	3 12	152 152	27.50	27.53	18.90	21.76	28.56%	8625	4475	52%
8	N.	3 38²⁄₅	152 153	24.59							
9	S.	3 35½	152 152	23.97	24.28	16.65	19.17	28.64%	5350	2720	51%
10	N.	4 45³⁄₅	126 126	19.62							
11	S.	4 6	126 126	20.87	20.25	13.80	15.89	29.09%	3020	1520	50%
			126			19.10	22.		9050	4700	52%
						13.90	16.		3100	1570	50%

RECENT SCREW-PROPELLER DESIGN.

Around no one item in all the component parts of the propelling machinery of a ship has controversy raged so frequently, and for so prolonged a time, as it has around the determination of the most suitable proportions for screw propellers. Even the question of watertube boilers versus those of the cylindrical type has aroused less criticism and occasioned less prolonged discussion than the ever-present problem of propeller efficiency. In spite of the hundreds of vessels built each year and the enormous amount of data collected on the subject, we are still far from finality; but there is no doubt that in recent years very considerable progress has been made, and it is by no means correct to assume, as has so often been done, that we are still no nearer a solution of the difficulty of determining the best proportions. On the contrary, those who are more intimately engaged in the designing of high-speed vesels, and who have access to the elaborate records that can now be obtained by the use of torsion meters and the greater facilties provided by experimental tanks for research work, are coming to the conclusion that we are, after all, very much more nearly approaching the maximum efficiency that we can obtain from the screw as a propeller under the circumstances in which it is used, and, what is of more importance, are now able to predict much more easily the best dimensions for given conditions.

The investigation of the efficiency of the screw as a propeller in general, of the various forms and proportions of screws, and of the relative efficiencies of various numbers and arrangements, has received an enormous amount of attention, especially in recent years. The original investigations by the late William Froude have been continued by his son, and the experiments of the early eighties have recently been carefully checked at the Royal Naval Experimental Establishment at Haslar and found to be very accurate. Among the more elaborate series of trials of model propellers, as opposed those

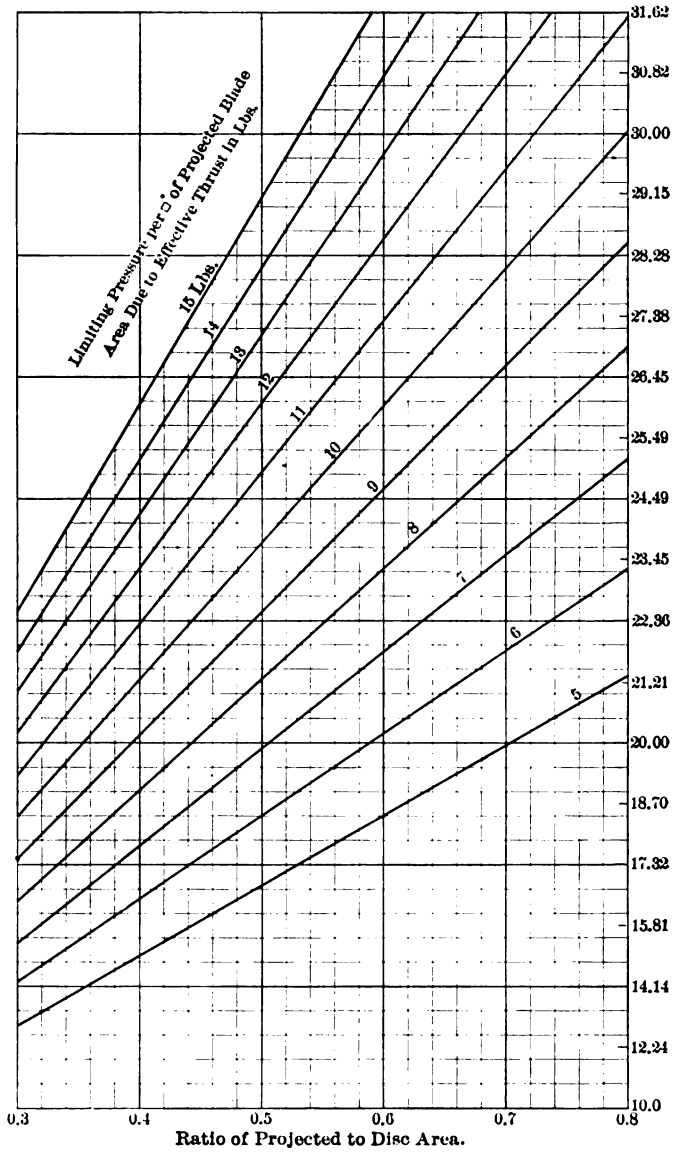

FIG. 1.—SPEAKMAN'S DIAGRAM FOR FINDING VALUES OF COEFFICIENT C.

on actual ships, we may mention the exhaustive series carried out by Messrs. Thornycroft, and published by Mr. S. W. Barnaby in his able book on screw propellers; the experimental investigations by the Hon. Charles Parsons on cavitation, which represented one of the most original scientific incursions into unknown phenomena of practical importance; the elaborate series of trials in the experimental tank at Washington by Naval Constructor D. W. Taylor, U. S. A., which were, with typical American generosity in scientific investigation, given to the world at the meetings of the American Society of Naval Architects; the recent experiments

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on blade sections and on cavitation at the Imperial German Experimental Tank at Charlottenburg, and Mr. R. E. Froude's recent experiments at Haslar.

Among the most valuable series of trials of full-sized propellers on various ships, we have those carried out by Mr. Yarrow in 1879, which were published in the *Engineer;* also innumerable cases of trials on long voyages of the same or of sister ships fitted with various forms of screws; the remarkable trials in 1900-1903 of the *Good Hope* and *County* classes, and of the *Hyacinth,* with different forms and proportions of propellers; of the *Daring,* when the phenomenon of cavitation was first brought into prominence as of commercial importance; the trials of the *Turbinia* by Parsons, that corroborated the laboratory experiments above referred to; the trials of the German cruiser *Lubeck,* with numerous different

But we are more particularly concerned with vessels of higher power and speed. Designers of such craft, especially of those of the destroyer type, are frequently faced by new phenomena that the constructors of slower and lower-powered vessels are not brought in contact with. Successful design is much more easy for the less arduous conditions, and our object is to emphasize those limiting features that are of such particular importance to builders confronted with new conditions.

For all practical purposes, reciprocating marine engines are obsolete for fast vessels, and it is hard to imagine any improvement that can reinstate them. Turbine machinery possesses such tremendous advantages that it is hardly worth while to consider the reciprocating engine propeller in these remarks. The turbine, whether of the Parsons or Curtis

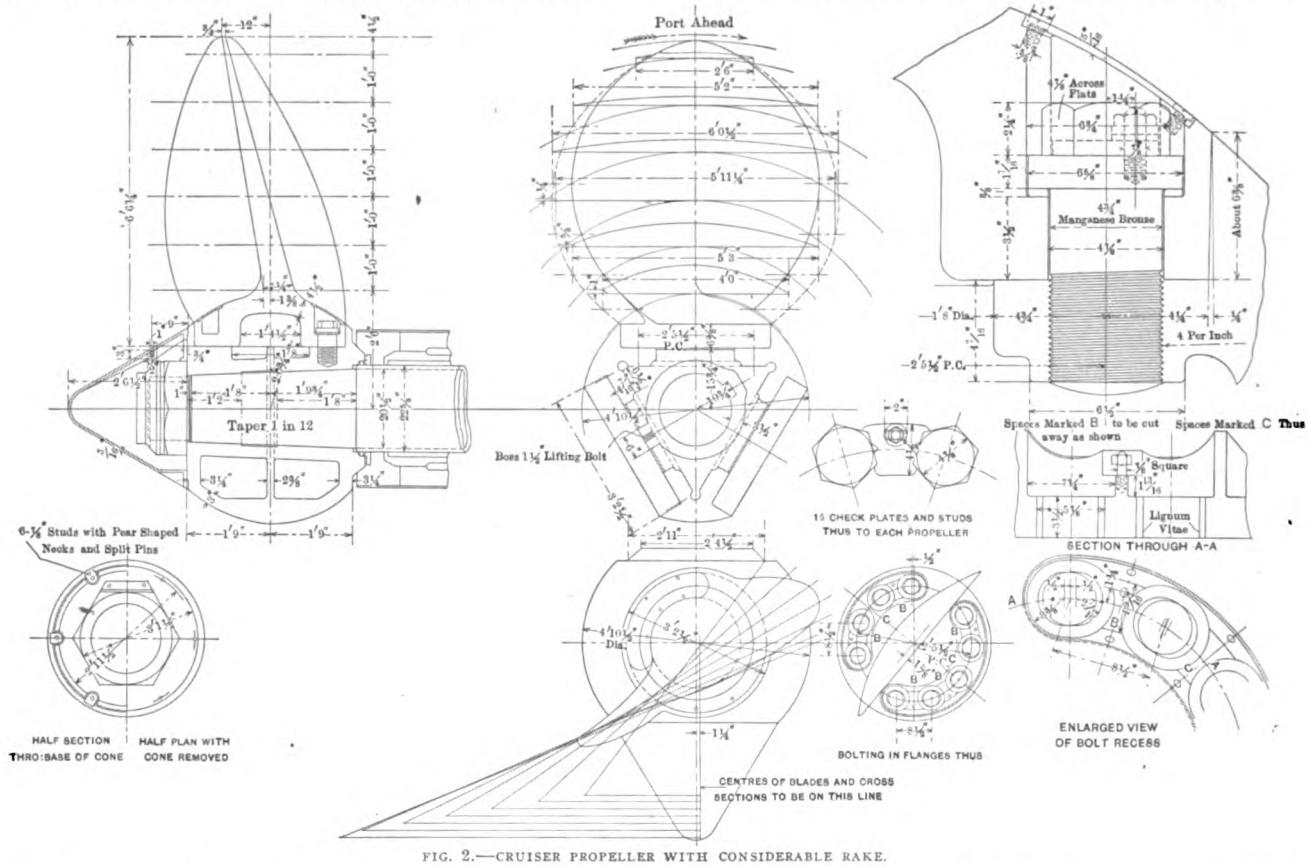
Port Ahead
Taper 1 in 12
Boss 1¼" Lifting Bolt
6-⅞" Studs with Pear Shaped Necks and Split Pins
HALF SECTION THRO: BASE OF CONE
HALF PLAN WITH CONE REMOVED
15 CHECK PLATES AND STUDS THUS TO EACH PROPELLER
BOLTING IN FLANGES THUS
CENTRES OF BLADES AND CROSS SECTIONS TO BE ON THIS LINE
Spaces Marked B to be cut away as shown
Spaces Marked C Thus
SECTION THROUGH A-A
ENLARGED VIEW OF BOLT RECESS
4⅞" Across Flats
4¾" Manganese Bronze
4 Per Inch
Lignum Vitae

FIG. 2.—CRUISER PROPELLER WITH CONSIDERABLE RAKE.

numbers, sizes and proportions of propellers, and still more recently the trials of the British ocean-going destroyers of the *Tartar* class.

The early history of screw propulsion demonstrates very clearly the groping into the unknown that was the inevitable burden of all the marine engineers of twenty years ago. That we have profited by the experimental nature of that work is as certain as it is that there are few who pause to contemplate the debt owed to former experimenters, and to render that tribute of thanks that they so thoroughly deserve.

While the power of steamships and the revolutions of the engines remained low, propellers were inevitably of enormous size in relation to the work to be done. As the revolutions have gradually increased, the propellers have decreased in size, till we are now at the extreme limit of reduced size, and are even inclined to go back to less exaggerated dimensions. An extreme comparison for 16-knot steamers might be made by comparing the *Great Eastern,* built in 1856, with another steamer built in 1906; the former had one screw 24 feet in diameter and 37 feet pitch, while the latter, of the same power and speed, has one propeller of 19 feet diameter.

type, has to run at relatively high speeds; the screw propeller, from considerations of efficiency—*i. e.,* friction and slip reduced as far as possible—should not run too fast, and some compromise between the two is essential. In some of the old torpedo boat destroyers of ten years ago, various very important phenomena were brought to light in connection with screw propulsion. It was found that not only did the peripheral velocity of the blades through the water become undesirably high, but that under certain conditions the water was unable to follow the blades of the screw, and a cavity was formed between the back of the blade and the water, which, though undoubtedly reducing the water friction on the screw surface, had the simultaneous effect of permitting the screw to race badly, and the loss due to increased slip was excessive.

Mr. Barnaby, the naval architect to T. I. Thornycroft & Company, who first traced the matter to its source, published a very full description of his investigations, which were subsequently corroborated by Parsons. It was found that the blades of a propeller which obtain their reaction from the water by their action on the water, act in different ways on their two

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faces. The after or driving face of a propeller exerts a push, and the forward side a pull upon the water. This pull is limited by the fact that the velocity that has to be imparted to the water in order for it to remain in contact with the blades at a depth h must not exceed $\sqrt{2\,g\,h}$ if the screw breaks the surface; but if it be sufficiently immersed to prevent air reaching it, the rate at which the water can be accelerated is much greater. Practical experiment showed that at a little depth below the surface of the water the tension exerted by the blade on the water could not exceed about 11 pounds per square inch without a cavity being formed, and that if the tension were increased the loss from slip increased very rapidly. Previous to the trials of the *Daring* and other destroyers of this period, the ratio of power to speed in torpedo craft had hardly ever been sufficient to cause this difficulty. Within wide limits this phenomenon of cavitation is unaffected by the diameter and pitch of the propeller. The important feature is projected blade area, because for a given thrust a given limit of tension per square inch can only be attained by adequate area. Mr. Barnaby gave an elaborate formula for this in his book on marine propellers, but based it on indicated horsepower and an assumed propulsive coefficient of 50 percent. Now, with turbine machinery it is impossible to calculate in terms of indicated horsepower, and effective horsepower alone can be considered.

The effective thrust along a shaft required for the propulsion of a given vessel is obtained from the formula $\frac{E.H.P. \times 33{,}000}{V \times 101.3}$, where V is the speed in knots. A simpler expression is $\frac{E.H.P. \times 326}{V}$. For a given limiting pressure of P pounds per square inch; the required projected area in square feet becomes $\frac{\text{thrust in pounds}}{P \times 144}$.

Mr. E. M. Speakman, now manager of the marine engineering department of Sir W. G. Armstrong Whitworth & Co., in a paper published in 1905, altered this formula so as to render it more rapidly applicable to purposes of design by including the ratio of projected surface to disk area, and converting the whole term into diameter in feet, so that a very simple expression is available. Mr. Speakman's diagram is given in Fig. 1; and provided the effective thrust is known—and this is an essential matter in turbine work—the coefficients given therein are extremely accurate. The formula in its most abbreviated form is:

$$\text{Diameter of propeller in feet} = \frac{\sqrt{\text{thrust in pounds}}}{C}$$ where

C is a coefficient having values ranging from 20 to 30 for various classes of ships. A figure, however, of 24 to 27 ensures excellent results, provided the pitch ratio is between 0.9 and 1.05. The following table gives some up-to-date values for C; others may be found for earlier turbine vessels in Mr. Speakman's papers to the American Society of Naval Architects or the Institution of Engineers and Shipbuilders in Scotland:

TABLE SHOWING VALUE OF COEFFICIENT C.

VESSEL	Speed	H. P.	Propeller Diameter	C.
H. M. S. Dreadnought	21.25	24,700 *	8′ 10″	25.0
R. M. S. Lusitania	25.4	68,000*	17′ 0″	21.5
H. M. S. Tartar	35.6	21,000*	6′ 0″	29.5
U. S. S. Salem	26.0	21,000*	8′ 1½″	27.0
H. M. S. Good Hope (a)	23.05	31,500	19′ 0″†	17.5
H. M. S. Good Hope (b)	24.11	30,700	19′ 0″	18.5
R. M. S. Kaiser Wilhelm	23.3	42,000	23′ 9″	17.9

† Taken with the torsionmeter † 30 percent greater area than (a)

With regard to the ratio of projected and disk area, a value of 0.5 to 0.6 seems to be most suitable for turbine work. In the *Daring* and the early destroyers it seldom exceeded 0.35, but has gradually increased. In the British ocean-going

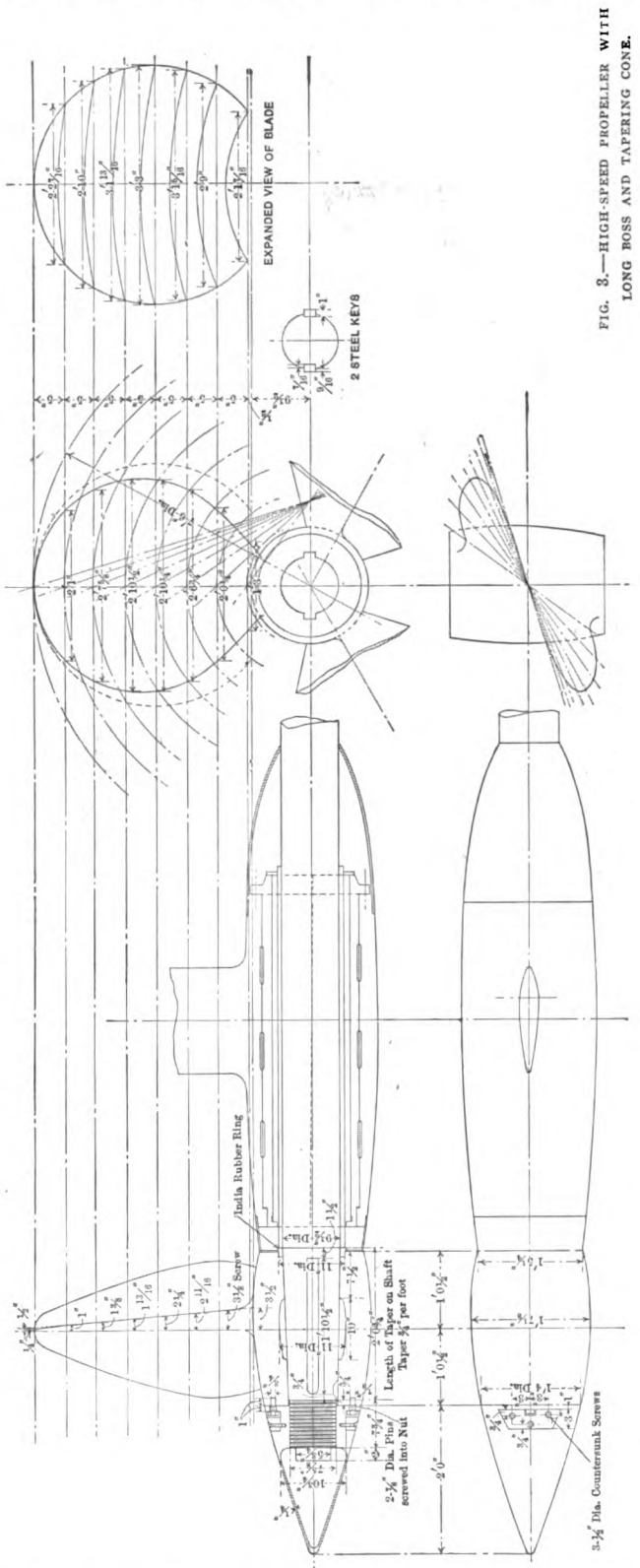

FIG. 8.—HIGH-SPEED PROPELLER WITH LONG BOSS AND TAPERING CONE.

vessels it was originally about 75 percent, but such a ratio was found to be excessive and more normal proportions were adopted. The good influence of rising from about 0.22 to 0.30 in the *Good Hope* is shown in the table; her early screws were deficient in area. The valuable experiments carried out

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by Naval Constructor D. W. Taylor have added widely to our knowledge of propeller proportions. The effect of rake of the generating line of the blade was tested at the Washington tank by him, and found to affect the result only very slightly up to 10 degrees from the vertical either way. It is really hardly worth while raking propellers very much aft, and most turbine propellers are made with the generating line vertical. An example of a cruiser propeller with considerable rake is

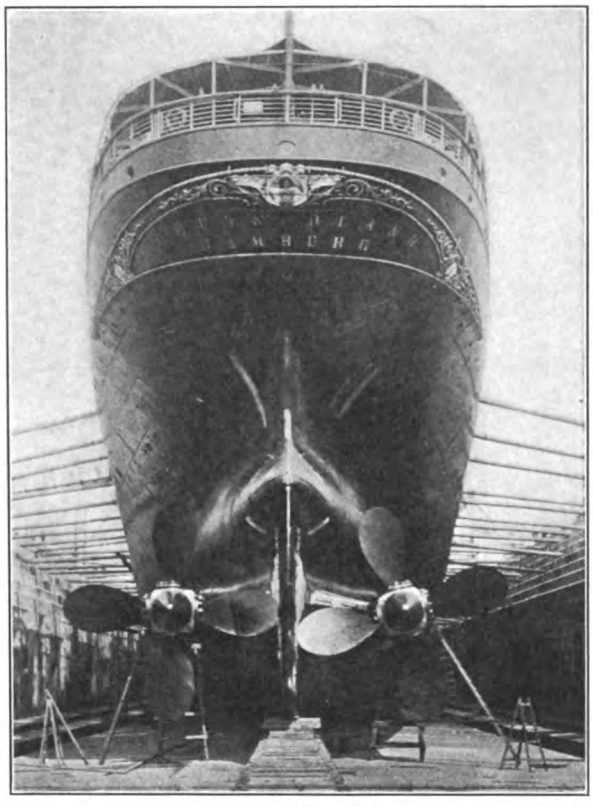

FIG. 4.—PROPELLERS OF THE DEUTSCHLAND.

shown in Fig. 2. Thickness of blade is of the greatest importance, and every effort should be made to reduce this to a minimum. Some difficulty will be found in doing so in turbine work in many cases, but the point should receive very careful attention.

The question of shape is an ever-interesting one. Experiments on both models and actual screws show that, provided the same area and thickness are maintained, shape alone has but little effect, and most turbine propellers are still made with circular blades in the projected view. An example is given in Fig. 3, where the long boss will be noticed as well as the tapering cone. This cone fulfills no idle purpose, as any student of the amazing cavitation photographs recently published by the Charlottenburg Tank Experimental Staff already knows. The high speed of rotation is apt to force the water clear away from the back of the boss, leaving an objectionable vacuous cavity that the cone is intended to fill or prevent. As will be seen in Fig. 2, little was done in this way some years ago, but every slight assistance is nowadays gladly accepted if any improvement in efficiency will result.

The question of the efficiency of modern screws is always interesting. That it has slightly fallen off with the introduction of the turbine was inevitable, but the over-all efficiency of propulsion is maintained at the same level by the more efficient engine. A figure of 70 percent has generally been regarded as the highest feasible for the screw propeller, and it is doubtful if this has ever been arrived at. Vessels like the *Kaiser Wilhelm* and *Deutschland,* whose propellers are shown in Fig. 4, have efficiencies of about 66 percent; those of the *Lusitania,* which will be much improved, were under 50 percent. The former figure is a very high one, as most naval propellers average 60 percent, and often less. Generally turbine screws exhibit efficiencies of between 50 and 55 percent. The exact determination of this efficiency rests on the accuracy with which we can determine both the brake horsepower and the effective horsepower. So little data is often available that inaccurate assumptions are frequently made, and the value of propeller efficiency, which is really very difficult to accurately determine, is only too often the subject of incorrect deduction or prejudiced assertion.

NOTES ON NAVAL SCIENCE TOPICS.

BY ARTHUR R. LIDDELL.

DECK CARGOES.

Closely connected with the question of stability is that of deck cargoes, which is now creating some attention in England and Germany.

The essential peculiarity of a vessel built to carry loads of timber on her deck is the variation in her effective depth—or perhaps height would here be the more appropriate term—which these bring about. Needless to say, a stack of timber on deck has buoyancy no less than a poop or a bridgehouse, and, provided it be thoroughly secured, it will have a righting moment of very considerable amount when the vessel lies over.

No vessel, of course, should be allowed to go to sea with a list, due to want or insufficiency of initial stability, but in practice a timber-carrier that is built for the trade, and has a large proportion of breadth to draft, will be safe against the danger of capsizing, with ever so small a *GM* height, even though she may have negative stability at angles of, say, 10 to 15 degrees.

It is well known that a high-sided vessel has a relatively wide range of stability, and this is the more true when the high side is made still higher amidships than at the ends. Beginning, it may be, with just enough initial stability to avoid taking a list, she then has a curve of righting levers which will, from angles of 15 to 20 degrees and onwards, steadily increase, up to very considerable inclinations (see Fig. 1).

The opposite case, of a vessel with deckloads or high erections at her ends, and a long gap in the middle of her length, will seldom come in question, though such cases are not altogether unknown. The curve of righting levers would in such case, perhaps, increase in height up to the point at which the gunwale becomes immersed, then diminish until it passes to the under side of the base line (becomes negative), and afterwards lie above the latter again at angles of about 45 to 90 degrees, somewhat as shown in Fig. 2.

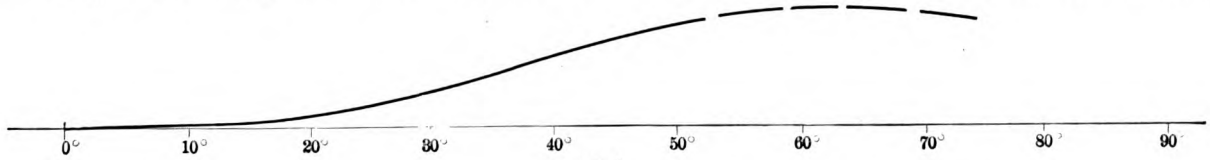

FIG. 1.

It follows from the foregoing that a broad, low vessel, increased in height by a deckload for, say, three-fourths length amidships, will be fairly safe against capsizing as soon as she

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has so much stability that she can stand upright without taking a list; and, since the tendency of a vessel with small initial stability to roll is very slight, her seagoing qualities may be good.

Now, while a vessel with very little initial stability, that is, with a very small *GM* height, may be in good sea trim, it would not do for her to commence a voyage under such conditions. In the first place, her stability may become altered, during the passage, by the presence of water in her bilges or double bottom; and in the second place, the departure conditions may be very considerably altered by the burning out of her bunker coal, by the absorption of water by the timber on deck, or by the ice which might accumulate on the cargo during winter voyages.

It may be laid down as a rule that a vessel leaving port must have a *GM* height greater than the smallest admissible one by at least as much as such height can from any assumable cause be lowered during her voyage. The question as to what is the least admissible *GM* height must be answered according to the circumstances of each case. For a vessel of, say, 250 to 300 feet in length, with a high deck load of timber stowed amidships, it may be as small as about 6 inches—in practice it is sometimes still less.

It may here be urged that the captain of a vessel is not a trained naval architect, and that her *GM* height can be ascertained only by a resort to a heeling experiment, which, at the best, takes a considerable time to make, and which can yield reliable results only in the very best of weather. In reality, however, a captain who is accustomed to such cargoes can "feel" when a vessel is getting tender by her movements while the cargo is being put on board and trimmed. If he observe the effect, voyage after voyage, of the last crane-loads of timber deposited on the side of the stack, he will soon be able to judge whether the resulting inclinations are too great, and know when it is time to cease taking in cargo.

The objection to a high deckload is not the want of stability of the fabric, although this will somewhere set a limit to the height. The danger is, that the timber may break adrift, or that it may be floated up from the deck when a sea breaks over the vessel, and, the lashings stretching somewhat, be deposited again slightly to one side of its old position, thus producing topsidedness. This tendency will show itself with every large wave which breaks on board, and the effect created by it will depend on the tautness and extensibility of the lashings.

Again, the extent to which the weight of the deckload may be increased by water soaking into or freezing into it is difficult to estimate. An ample margin of *GM* height should, especially during the winter months, be allowed for this.

What has been said above in regard to deckloads applies, in part, also to erections, such as inclosed poops, bridge houses and forecastles. A vessel with a bridge house extending over half her length is considerably better off as regards stability than one with a poop and a forecastle, each extending over a quarter of the length. Assuming the freeboard to have been reduced on the strength of such erections, the respective curves of levers of the vessel may in the former case show ample stability to angles of 50 or 60 degrees, and in the latter show a deficiency at angles of from 15 to 45 degrees, which is not made good by unusually large stability at angles between 50 and 90 degrees.

In the assessment of freeboard for vessels with deck erections, it would be desirable that this circumstance should receive more consideration that has hitherto been given it. The points which, in the apportionment of freeboard, have hitherto received most attention have been height above the water of the platform on which the crew is to work, sufficiency of reserve buoyancy, and strength of the general structure. If we grant that stability be a quality which varies too much to admit of definite assessment, it might still be practicable to put certain limits to the proportions allowed to be borne by a vessel's dimensions, one to another, and to the distribution of the reserve buoyancy too much towards the ends of the vessel, as producing a state of things which will, under ordinary conditions of loading and stowage, make for danger.

If the issue by the state of further regulations for the loading of vessels be deprecated, it may still be desirable to establish rules for the guidance of naval architects and shipowners. The application of the equivalent block method described might here also be of advantage.

The metacenter and the center of gravity of the block being exactly determinable points, the amount of freeboard necessary to insure a given range of stability and given height of lever curve—for the block—are also fixtures, and the elaboration of tables for different relations of breadth, depth, freeboard, and fineness of vessel, one to another, which would sufficiently give the conditions likely to occur in practice, would be simply a matter of work. Such tables once made, it would be possible, for any proportions of depth to breadth, to pick out the freeboard corresponding with a desired average or extreme range of stability and height of lever curve. As has been shown under the head of stability, the conditions thus given for the equivalent rectangular block differ from those for the vessel by amounts not very great in themselves. These differences can, by competent authority, be approximated with tolerable exactness.

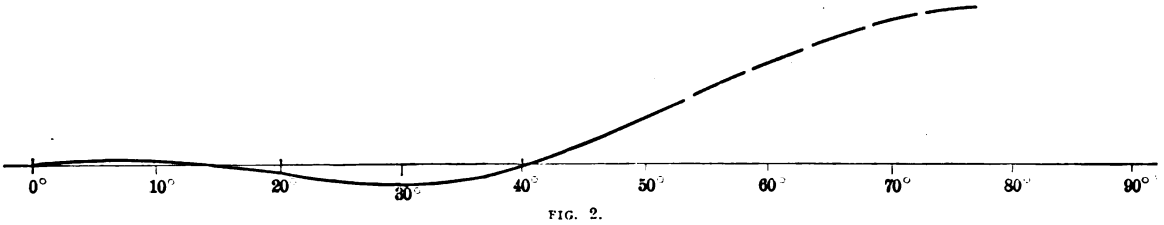

FIG. 2.

THE AMERICAN SAILING SHIP.

BY CAPTAIN GEORGE L. NORTON.

From 1846 to 1860 was the most important period in the history of the merchant marine service of the United States; as it was during those years that her ocean-going tonnage reached its highest figure and gradually began its decline. It was during this fifteen-year period that the famous American clipper ships attained their world-wide eminence and began to drop out. This period is also memorable for the beginning of the short-lived American lines of transatlantic steamships, which opened with the promise of renewed and absolute mastery of the ocean-carrying trade and closed beneath the shadows of actual or impending defeat with the beginning of the Civil War. At the end of the war the American merchant marine in the foreign trade practically met its death blow; namely, the competition of foreign subsidized ships, built by cheap labor and operated by the same, causing American capital to look landward for investment, with the result that, while the United States now has the greatest and most efficient railroad service in all the world, her over-sea shipping has dwindled almost out of existence.

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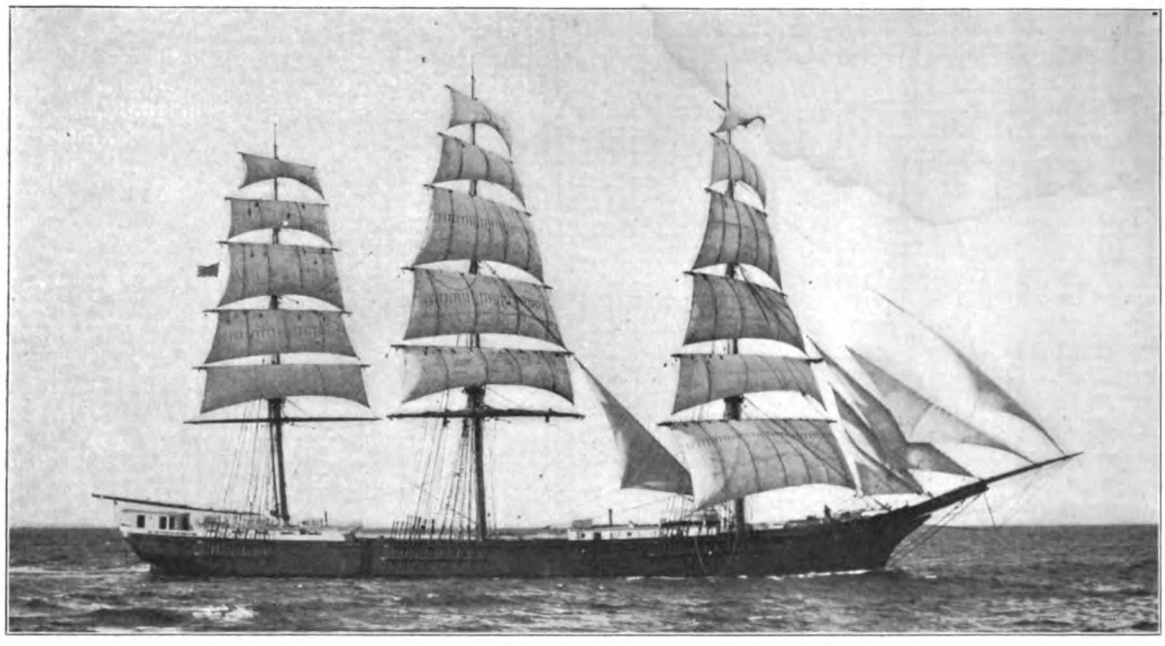

FIG. 1.—A FULL-RIGGED SHIP UNDER EASY SAIL NEARING PORT.

America's protected coastwise fleet of steam and sail vessels has increased in numbers, and the ships have grown in size, until it can now be said that, probably, no foreign fleet can be compared with these vessels in beauty of model, size, stanchness of construction and capacity to handle and carry cargoes of enormous proportions. As a consequence, these ships are always more or less prosperous. It is safe to predict, however, that the exclusion of American ships from the deep-sea trade is only for a time, and for a brief time at that, as no race with a grasp upon two oceans and the mingled blood of the Viking and pioneer can long be cheated of its birthright.

The illustrations herewith presented will give the eye of the admirer of sailing craft a treat seldom enjoyed in these days of continued illustrations of steam vessels. Sailing vessels are seldom considered, as they have become a non-paying investment in most foreign-going trades. A class of vessel, however, that has kept pace in growth with the coastwise and

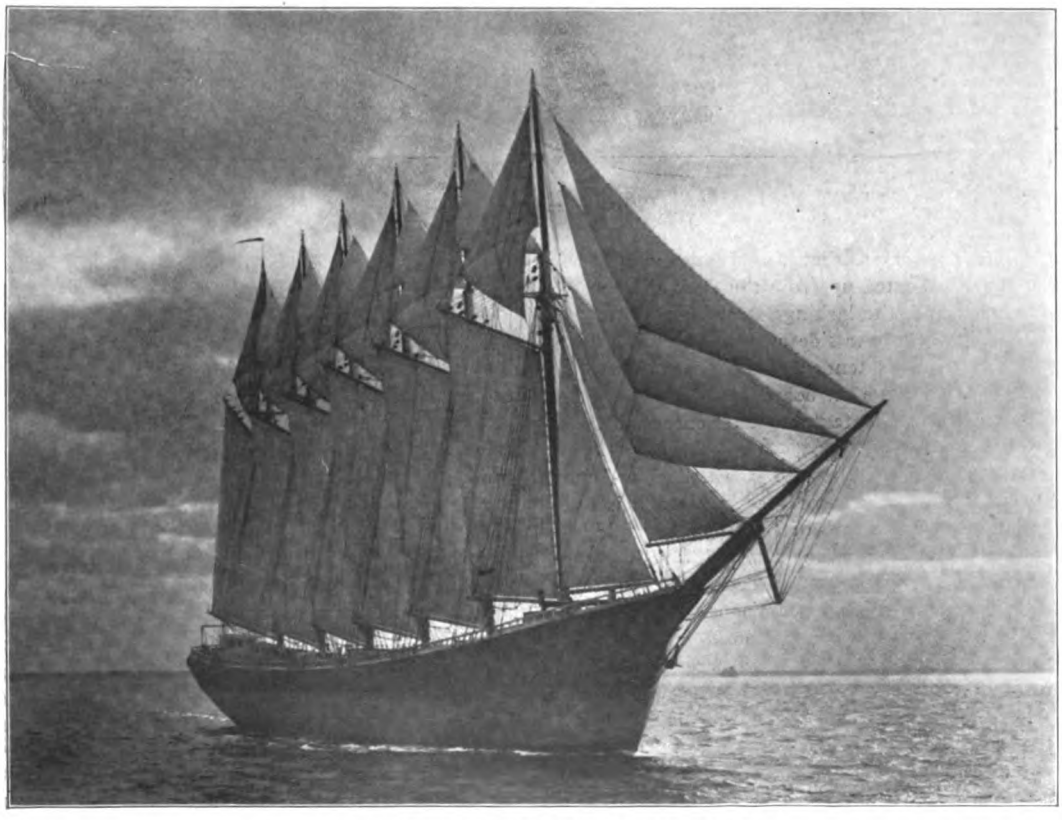

FIG. 2.—SIX-MASTED SCHOONER "FULL AND BY."

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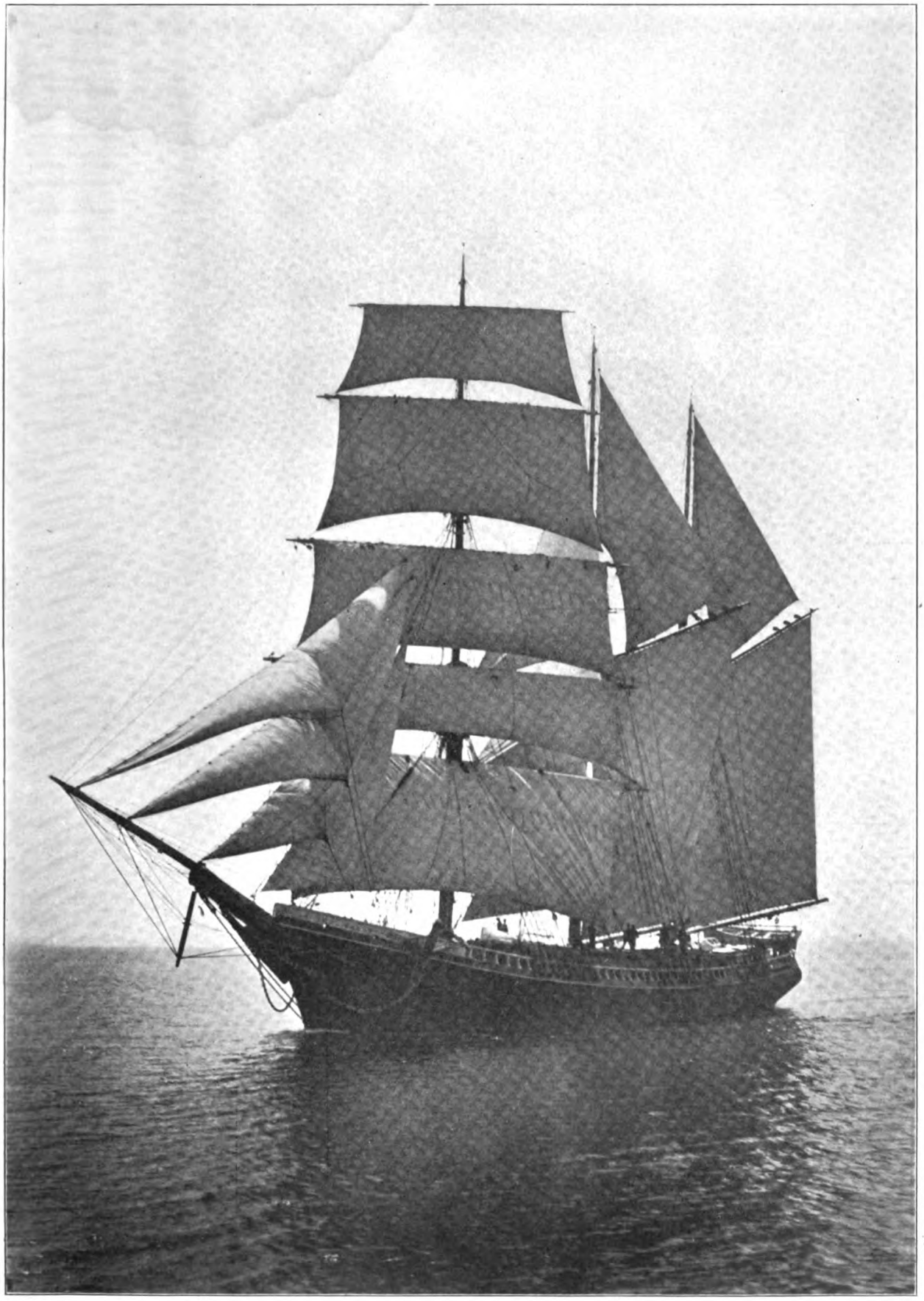

FIG. 8.—BARKENTINE UNDER SAIL.

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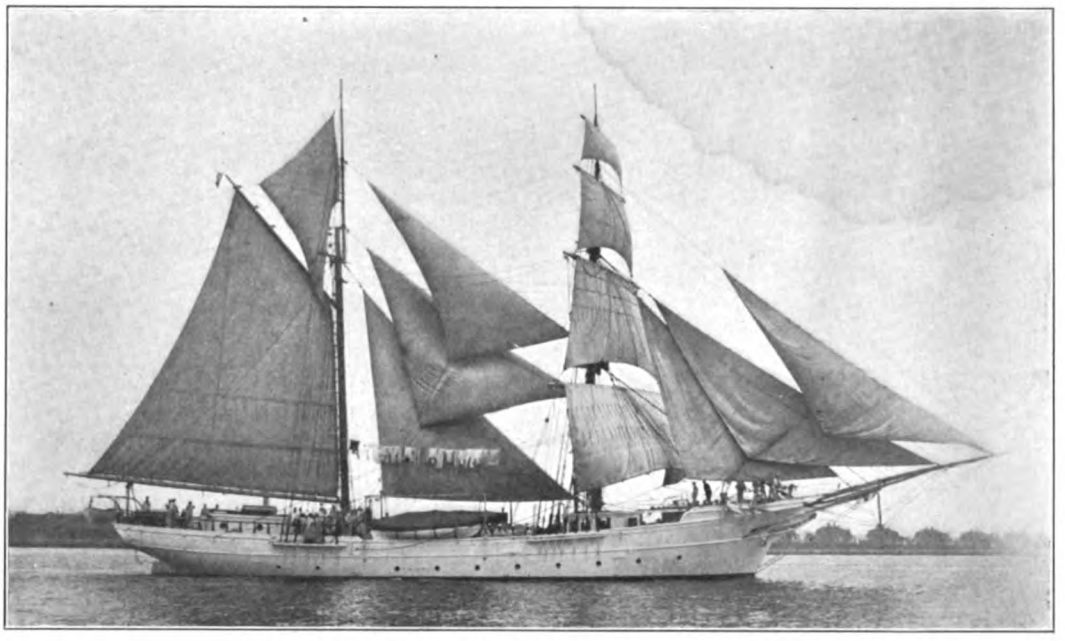

FIG. 4.—U. S. BRIGANTINE BOXER.

large fleet of steamers on the Great Lakes is the four, five and six-masted schooner. One seven-master, the *Thomas W. Lawson,* of 5,218 tons, was built in 1901. The *Lawson* was capable of carrying 8,000 tons of coal, but was a little too unwieldy at sea with her large number of heavy lower sails, and a misfit generally at the coal wharves and chutes in loading and discharging, besides being shut out of some ports

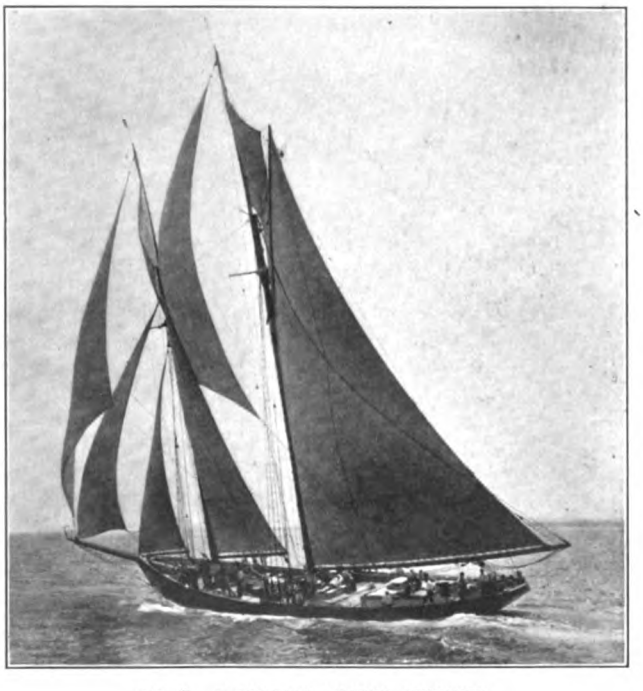

FIG. 5.—GLOUCESTER FISHING SCHOONER.

where coal cargoes had to be landed in narrow rivers and above bridges. This vessel was lost nearly two years ago, and her loss has doubtless ended the career of seven-masted schooners. The four, five and six-masted schooners however, are ideal craft for 'longshore colliers; and as they are a style of craft that has come to stay in the coastwise trade, as well as in the ocean-going trade when business warrants, a brief history of the schooner from its beginning is of interest.

The first fore-and-aft, two-masted vessel was built at Gloucester, Mass., by one Captain Andrew Robinson, and it is said that its name was derived from the fact that a bystander at the launch, as she struck the water, exclaimed: "See how she scoons!" "If she scoons," remarked her builder, "she must be a schooner"—hence the name. The first three-masted schooner, the *Zachary Taylor,* was built in 1849, in Philadelphia. Her mizzenmast was shorter than her fore and main masts, the only noticeable difference in rig between then and now. She was of 250 tons gross and her first voyage, which was to Aspinwall and return, was a success. The *W. L. White* was the first four-masted schooner, and was built at Bath, Me., in 1880, by Goss, Sawyer & Packard, on the site of what is now the plant of the New England Shipbuilding Company. This vessel was of 995 tons gross. The *Governor Ames* was the first five-masted schooner and was built at Waldoboro, Me., in 1888; and although she has been dismasted twice, she is still in service. She is 1,778 tons gross. Camden, Me., produced the first six-masted schooner; namely, the *George W. Wells,* of 2,970 tons gross, in 1900. Since that time there has been quite a number of this class of vessels built. On Nov. 10, 1908, there was launched from the yards of Percy & Small, at Bath, Me., a monster five-masted schooner of 2,989 tons gross. When launched, this vessel could have proceeded to sea at once, as she had her sails bent and crew and stores on board, a degree of completion at launching not uncommon in this the greatest of wooden shipbuilding ports of the United States, and from which have been launched some of the best-known sailing vessels maritime nations have ever seen.

Reports from the Commissioner of Navigation in 1906 show that up to that time four calendar years had elapsed since a square-rigged vessel was built in the United States. Two years previous to that date the prediction was made that at the present rate of decrease, the remaining square-rigged fleet would totally disappear in less than twenty years. Since then, up to the latter part of 1906, there has been a decline of 14 percent in number and 11 percent in tonnage of these vessels, so that at the beginning of the year 1906 this fleet numbered only 276 vessels of 322,288 gross tons. In the years preceding 1890, when conditions began to render the operation of square-rigged vessels unprofitable, many of these were dismantled and converted into barges. This practice has con-

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tinued, although since 1890 a large number of wooden and steel barges have been especially constructed for carrying coal, oil and other bulk cargo.

Bureau Veritas reports for 1908 show that the total net tonnage of sailing ships in the world, including only ships of 50 tons net and upwards, is 6,993,730 tons, of which 1,408,513 tons, or 20.15 percent of the whole, is credited to the United States. The aggregate tonnage of United States sailing ships is exceeded only by that of English ships, which amounts to 22.75 percent of the whole, and it is more than twice as large as that of any other country.

While the total gross tonnage of United States shipping has increased 54.2 percent during the seventeen years from 1889 to 1906, this has been due, largely, to the increase in tonnage of steam vessels and unrigged craft; for the tonnage of sailing vessels has increased only 1.7 percent during this period, while the total number of sailing vessels has decreased 10.2 percent. Of the total number of sailing vessels

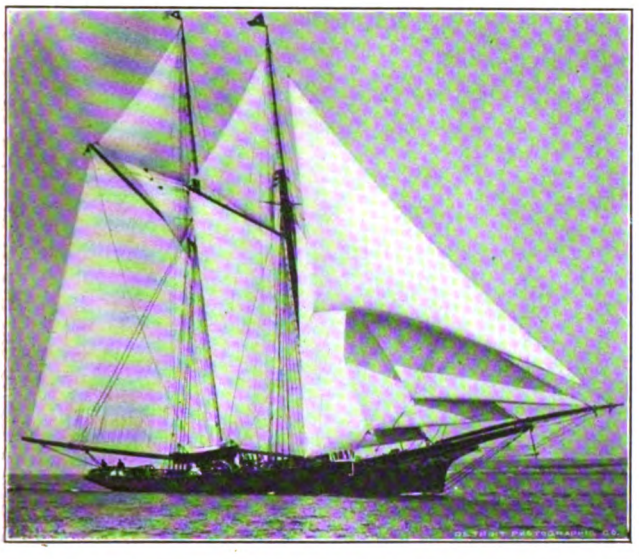

FIG. 6.—DAUNTLESS—TYPICAL AMERICAN YACHT OF THE SEVENTIES.

classed by the American Bureau of Navigation in 1906, 5,181, or 72.7 percent, are engaged in freight and passenger trade. These represent 98.2 percent of the gross tonnage, and 91.5 percent of the total value of sailing ships in the United States. The remainder includes yachts and small craft. The tonnage of these merchant sailing vessels is distributed as follows: 66.5 percent on the Atlantic Coast and Gulf of Mexico; 17.9 percent on the Pacific Coast, and 15.6 percent on the Great Lakes and St. Lawrence River. During the seventeen-year period from 1889 to 1906, the tonnage of sailing ships on the Atlantic Coast and Gulf of Mexico decreased 12.4 percent, while that on the Pacific Coast increased 56.1 percent, and that on the Great Lakes and St. Lawrence River increased 43.5 percent.

While it is a source of great regret that the American ship in the over-sea trade is practically a relic of the past, the American people can get some consolation by referring back to the historians before the Civil War, where we find that American ships were in the first rank, and certainly the equal of those of other shipbuilding and shipowning countries, and that the men who commanded them were the peers in ability, learning and standing of other maritime nations. Lindsay, the historian of the British merchant marine, who had been a sailor as well as shipowner, says in his authoritative work, "During the first half of this century, the masters of American vessels were, as a rule, greatly superior to those who held similar positions in English ships, arising in some measure from the limited education of the latter, which was not sufficient to qualify them for the higher grades of the merchant service. American shipowners required their masters to have not merely a knowledge of navigation and seamanship, but also of commercial pursuits, the nature of exchange, the art of correspondence, and a sufficient knowledge of business to qualify them to represent the interests of their employers to advantage with merchants abroad. On all such matters the commanders of English ships, with the exception of the East India Company, were at this period greatly inferior to the commanders of United States vessels."

A committee of the House of Commons, in 1836, had spoken of the "vast superiority in officers, crews and equipment, and the consequent superior success and growth of American shipping." The British Consul for Maine and New Hampshire, in a report to the Foreign Office, in 1847, said: "Education is much prized by the citizens; many vessels, therefore, are commanded by gentlemen with a college education and by those educated in high schools, who, on leaving these institutions, enter a merchant's counting room for a limited time before they go to sea for practical seamanship, etc., or are intrusted by their parents, guardians or friends with the command of vessels."

Such was the acknowledged superiority of the American merchant officers at the time when Great Britain began to overwhelm her sailing fleet with mail subsidies, which were in large part virtually bonuses upon the steamship and iron shipbuilding industry. If subsidy had been met with subsidy, and this protectionism been adhered to as tenaciously as Britain did, and the same encouragement had been offered to iron shipyards that was given to cotton mills and the iron industry in general by high duties after 1860, the splendid officers and seamen of the American merchant marine would have won the fight, in spite of the temporary havoc wrought among United States sailing vessels by the Civil War. Great Britain stood loyally by her shipowners, and with constant and unceasing subsidy protection tided them over their years of trial and misfortune. The United States deserted her shipowners in their time of need, leaving them to fight single-handed the hazards of the sea, the vicissitudes of the unfamiliar trade of steam navigation and the treasuries of foreign governments. Who can wonder that they were beaten in this unequal contest, and driven from the sea?

Ventilation by Induced Currents.

At the Institute of Marine Engineers, on Dec. 5, a paper on "Ventilation by Induced Currents" was read by Mr. Robt. Gregory. The system described by Mr. Gregory consisted of a nozzle placed in a series of corrugated tubes of different sizes telescoped into one another, and so arranged that at each diminishing diameter an annular space remained between the tubes of sufficient area for the vitiated air to flow in at the junctions, thus carrying off the foul air or gases. The nozzle was fitted into the smallest tube, and was connected to an accumulator or reservoir of compressed air, supplied by a small air compressor. Pipes, fitted with a regulating valve, could be carried from the accumulator to each compartment or hold, and there connected to their respective ventilators, which could be used either as downcasts for fresh air or as upcasts for exhausting the foul air. Instead of compressed air a centrifugal fan could be used for supplying air to the nozzles, and by means of hot air chambers the air could be heated for the purpose of warming the cabins or saloons.

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THE NEW TWIN-SCREW MAIL STEAMER MOREA.

Designed for fast mail and passenger service to India and Australia, the new twin-screw steamer *Morea,* which has just been completed by Barclay, Curle & Co., Ltd., at their Clydeholm shipyard near Glasgow, comprises the most recent addition to the large fleet of the Peninsular & Oriental Steam Navigation Company, Ltd. The keel of the vessel was laid Nov. 6, 1907, and she was launched Aug. 15, 1908, or within a period of nine months and one week. Three months more were required for fitting her out, and she was taken out for her official trial trips on Nov. 5, 1908, or exactly twelve months after construction was begun.

The principal dimensions of the vessel are:

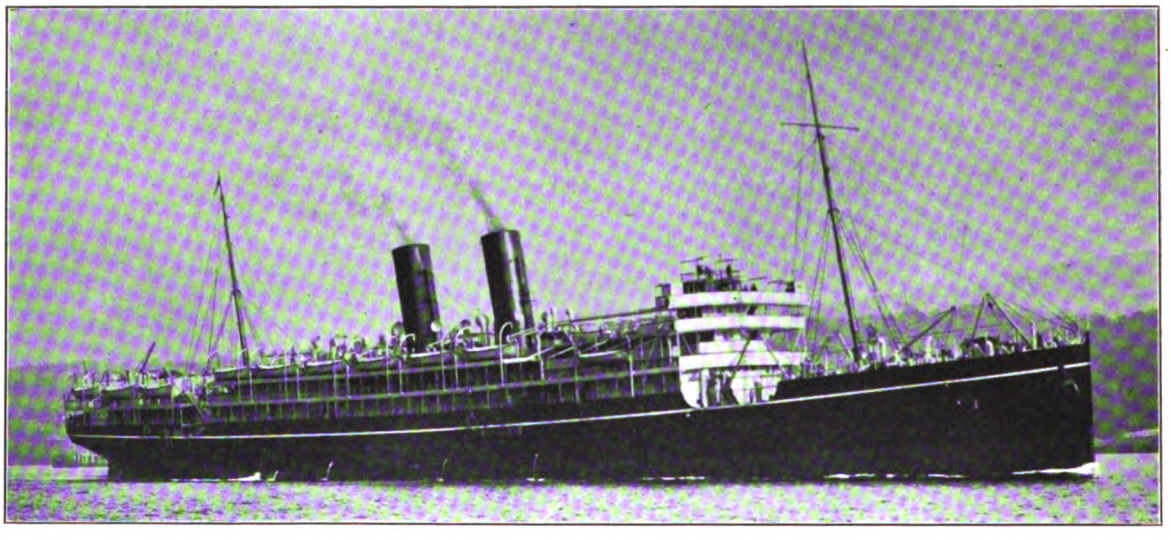
Length	560 feet 0 inches
Breadth	61 feet 6 inches
Depth	39 feet 0 inches
Gross tonnage	11,500
Designed speed	18 knots
Number of first class passengers	407
Number of second class passengers	200

The *Morea* was built under the supervision of the Peninsular & Oriental Company's own staff of inspectors, to the requirements of the Board of Trade for a foreign-going passenger steamship, and under special survey of Lloyd's.

The hull is of Siemens-Martin mild open-hearth steel, the scantlings being considerably in excess of the requirements of Lloyds. It is divided into separate watertight compartments in order to provide for safety, a complete inner bottom being fitted all fore and aft with numerous watertight bulkheads dividing the hull transversely. There are four complete decks—viz: orlop, lower, main and upper—sheathed with teak and yellow pine. Above the spar deck, at the fore end, is a long forecastle, amidships the hurricane deck, and at the after end the poop deck. Above the hurricane deck is the first class promenade deck, extending for 300 feet amidships. The second class promenade deck, 180 feet long, is situated above the poop deck. Above the midships promenade deck is the boat deck, at the fore end of which are the captain's and officers' rooms, surmounted by a wheelhouse and two flying bridges.

The arrangements for passenger accommodations have been designed to give the maximum space and comfort to each individual. The first class passengers are all berthed amidships; the sleeping cabins being placed on the main, spar, hurricane and promenade decks. The general practice of placing a number of cabins on the promenade deck has been adhered to. The dining saloon, a large and spacious apartment, is situated on the spar deck at the fore end of the bridge space and extends the full breadth of the ship. A feature of this apartment is its great height and the large open well overhead, which extends through three decks to a large dome of stained glass on the boat deck. Electric bells, fans and lights are provided here as elsewhere throughout the vessel. A handsome double stairway at the after end of the dining saloon leads to the hurricane deck entrance hall, aft and forward of which are placed the divan and music rooms. At the after end of the promenade deck is situated the first class smokeroom, a spacious and well-appointed room, with a large lighting well overhead. The paneling of all the public rooms is of fumed oak, with fibrous plaster ceilings, the whole of the decoration being carried out by the builders to designs supplied by Messrs. Collcutt & Hamp, of London. The sanitary accommodations are fitted up in numerous small blocks each complete in itself, placed at different points throughout the passenger accommodations, so as to make them readily accessible. Baths with hot and cold water, hot and cold showers, hand wash basins, and all other necessaries are provided in numbers in excess of the usual complement.

The second class passengers are accommodated towards the after end of the vessel, and everything is provided for them on a scale and in a style only inferior to the first class; the dining-room, smoking room, entrance hall and sanitary accommodations being all arranged with the same care and attention as the first class.



THE NEW P. & O. MAIL STEAMER MOREA.

The stewards' department, one of the most important on a passenger steamer, has received due attention. Large store rooms are provided on the orlop deck, together with a refrigerating chamber with separate compartments for preserving perishable provisions; also an ice-making room, the temperature of these chambers being kept at any desired point by a refrigerating machine on the dry-air principle, placed in engine room. In addition to this, a large refrigerating installation is fitted for the purpose of carrying meat cargoes in the forward holds, which are insulated for the purpose.

The galleys are placed on the spar deck and are fitted up with all the usual appliances. Adjacent are the bakers' shop, with dough-mixing machines, dish-washing machines, etc., butchers' shop, scullery, vegetable room, etc. Large pantries are fitted, adjoining each dining saloon, with hot and cold water and carving tables heated with steam.

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On the spar deck, at the after end, is situated a large post office replete with sorting tables and every other device necessary for the expeditious handling of mails, while on the main deck is a supplementary sorting room, so that a more than ordinarily heavy mail may be handled. The mail rooms for India, China and Australian mails are situated on the lower deck.

The Lascar crew are berthed at the extreme after end, under the poop, while the British crew and stewards are accommodated forward on the lower, main and spar decks. The engineers are on the spar deck, alongside the entrance to the engine room.

A large chart room and wheelhouse is provided, containing the steering wheels and other navigating appliances, including Kelvin compasses, engine-room telegraphs, docking and steering telegraphs, speaking tubes, and loud-speaking telephones to the engine room, forecastlehead and after end of the vessel. The steam-steering gear is in a steel house immediately over the rudderhead, actuated by telemotor gear from the bridge, and aft a hand gear is fitted for emergencies.

The propelling machinery consists of two sets of four-crank, quadruple-expansion engines balanced for smooth and silent working. On her trial trip the engines developed sufficient power to give the vessel a speed of over eighteen knots.

Steam is supplied by eight boilers working at a pressure of 215 pounds per square inch, four of which are double-ended and four single-ended. Collectively, there are thirty-six furnaces, all supplied with Howden's system of forced draft, operated by four large electrically-driven fans. All of the piping is covered with a patent insulating covering, supplied by Messrs. Matthew, Keenan & Co., Ltd.

The outfit of auxiliary machinery in the engine room is unusually comprehensive, and includes fourteen separate steam pumps, an ash expeller whereby the ashes are forced out through the bottom of the ship, and a feed-water evaporator and filtering plant is fitted both in the engine room and in conjunction with the refrigerating machinery.

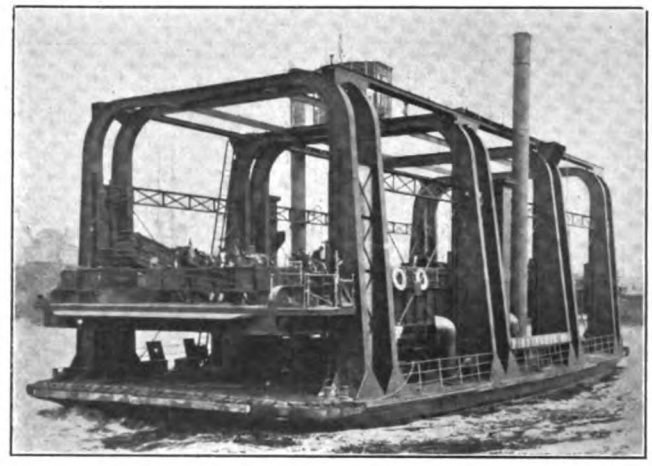
The electric light installation consists of five independent dynamos, each driven by compound coupled engines; and in addition, an emergency dynamo is fitted complete with a boiler in connection with the passage, deck and masthead lights. The ventilation of the vessel is unusually complete for hot climates and, in addition to the usual methods, electric fans are fitted throughout.

The appliances for mooring the ship include a large steam windlass, two steam capstans forward, and two steam warping capstans aft. The cargo loading and discharging facilities are very complete, eight cargo hatchways being served by ten powerful hydraulic cranes, which operate with little noise—a fact which will be much appreciated by passengers.

A UNIQUE FERRYBOAT.

An elevating vehicular ferry steamer was recently constructed by Messrs. Ferguson Bros., Port Glasgow, for the trustees of the Clyde Navigation for service in Glasgow harbor at Finneston. This vessel, which is known as the *Finneston No. 1*, is 104 feet long, 45 feet wide, with a molded depth of 12 feet 6 inches. She was built to British Corporation Survey requirements, and has a Board of Trade certificate for carrying passengers.

The elevating platform which carries the vehicles has a range of 17 feet, and is carried on eight double-threaded buttress screws of forged steel, the screws being hung on collar bearings in cast steel brackets, which are supported by the framing legs. The platform is built up of H girders, closely pitched and connected at the ends to massive built steel girders on either side of the vessel. The supporting screws are fitted with worm wheels, of special material, at the lower ends gearing with forged steel worms all working in oil baths. A separate triple-expansion three-crank engine is fitted for the purpose of raising or lowering the main platform. This engine is of the inverted type, and connects to the worms by machine-cut bevel and spur gearing of cast steel, an automatic gear is fitted on this engine to prevent the platform from being raised or lowered beyond its intended travel. A brass indexed tell-tale is also fitted in a prominent



FINNESTON NO. 1.

position in the engine room, showing the exact position of the platform in feet and inches.

The lower or main deck is of steel plating, and has no projections above 10 inches, allowing the platform to come to the lowest possible level during a very high tide.

The main propelling engines are of the vertical three-crank triple-expansion type, each engine driving two propellers, one forward and one aft, two thrust blocks being fitted on each line of shafting. The engines are controlled from the house on top of the framing by balanced rods, the latter actuating the steam valves on the direct-acting steam and hydraulic reversing engines. There are no rudders, the vessel being maneuvered entirely by the propelling machinery. In the controlling house the two reversing handles are situated one on each side of the steersman's position. Two Chadburn's direction tell-tales and tachometers are also provided and fixed in this house, giving the number of revolutions and direction of the propelling engines. Chadburn's telegraphs to the main and elevating engines are also fitted, the former being intended for use only in case of emergency.

Steam is provided by two return tube marine boilers, having a working pressure of 160 pounds per square inch. The main condenser is separate from the main engines, and is fitted with two of Baker's exhaust steam purifiers. The air pumps are independent, steam driven by two crank compound engines, and are in duplicate, one set being kept as a stand-by. This also applies to the independent centrifugal circulating pumps. Electric light is fitted throughout.

The boiler feeding is effected by Weir's automatic float-tank pumps, the feed-water passing through a Weir's heater and Harris filter before entering the boilers. Cameron's pump is fitted for bilge and wash-deck service.

The vessel throughout is of massive design, all parts having been carefully constructed for their respective purposes. The platform is intended to carry sixteen loaded lorries, but with a mixed cargo as many as twenty vehicles can be accommodated on board.

The vessel was launched with all her machinery on board and with steam up.

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A LONGITUDINALLY-FRAMED SHIP.

BY BENJAMIN TAYLOR.

The oil tank steamer *Paul Paix*, built by Messrs. R. Craggs & Son, Ltd., Middlesbrough, for the Lennards Carrying Company, Ltd., has the distinction of being the first ship built on the Isherwood system of construction, in which longitudinal framing takes the place of the closely-spaced transverse frames familiar in ordinary vessels. With this system of construction, transverse strength is obtained by fitting on the shell and deck plating a series of strong transverse members at widely-spaced intervals. These transverses extend completely around the sides, bottom and deck of the ship and are slotted to permit longitudinal frames and beams being fitted continuously throughout the length of the ship. It is claimed that by using this system of construction the ship can be built of greater strength with the same weight of material than when the ordinary form of framing is used, or, that the same strength can be obtained with a less weight of material. It is also claimed that construction is simplified, and that the dead weight carrying capacity is considerably increased.

The *Paul Paix* is an oil tanker, subdivided into sixteen separate oil tanks, designed to carry 6,400 tons dead weight, and special arrangements are made to enable her to load down to full load draft with a cargo of motor spirits with the same facility as with denser oils. The ship is 367 feet long over all, with an extreme beam of 49 feet 6 inches and a molded depth of 28 feet. She is a single-deck ship, having a continuous expansion trunkway above the oil tanks. Propulsion is by means of quadruple expansion engines fitted amidships, steam being supplied by three main boilers abreast. There are two complete cargo-pumping installations of unusual power, designed to deliver the fuel cargo into shore tanks in a few hours.

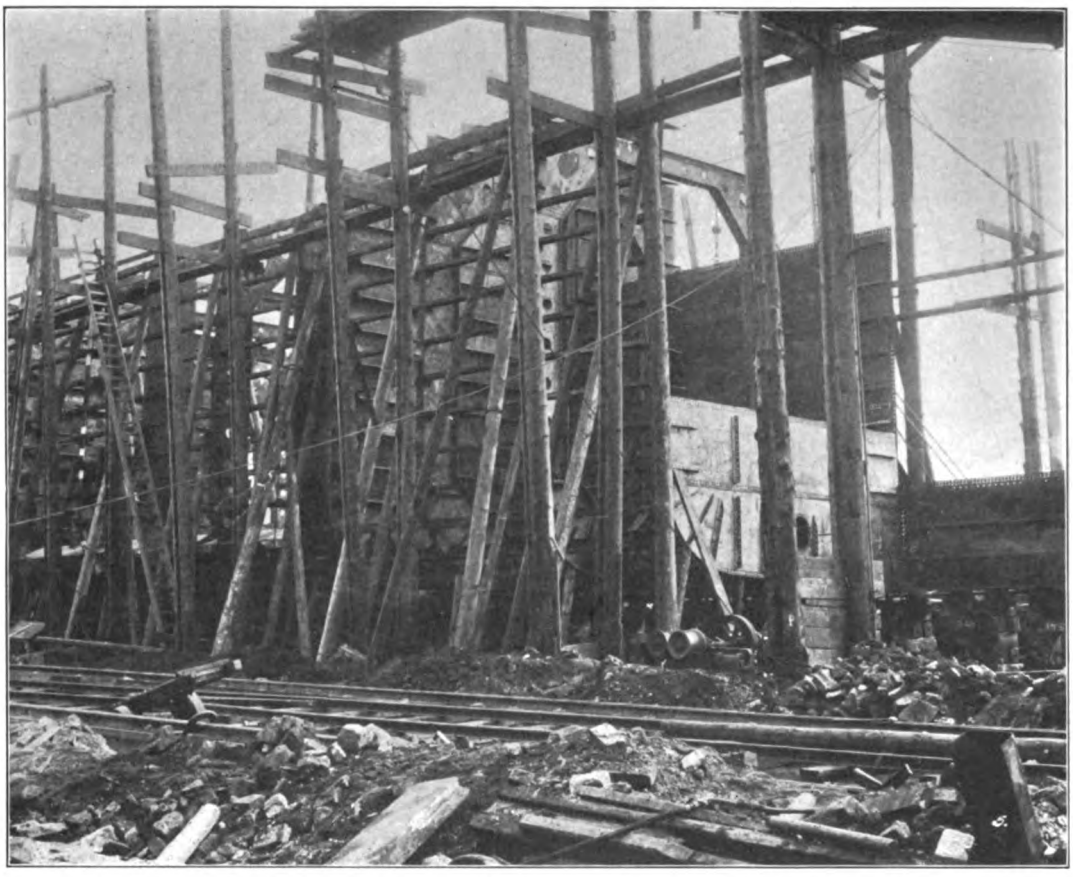

FIG. 1.—VIEW OF THE PAUL PAIX, UNDER CONSTRUCTION, SHOWING STRONG TRANSVERSE MEMBERS.

The coaling arrangements are very simple and very little trimming is necessary, the cross bunker forward of the boiler room (A, in Fig. 2) being the main permanent bunker. The bridge space is utilized for reserve bunkers. A double bottom, available for carrying oil fuel or water ballast, is fitted in the machinery spaces.

In order to avoid any break in the longitudinal strength, the trunk is continued through the bridge, and the arrangements provide for practically the same longitudinal strength through the machinery space as in way of the oil tanks at each end of the bridge, the omission of the center bulkhead being compensated for by the longitudinally-stiffened bridge and double

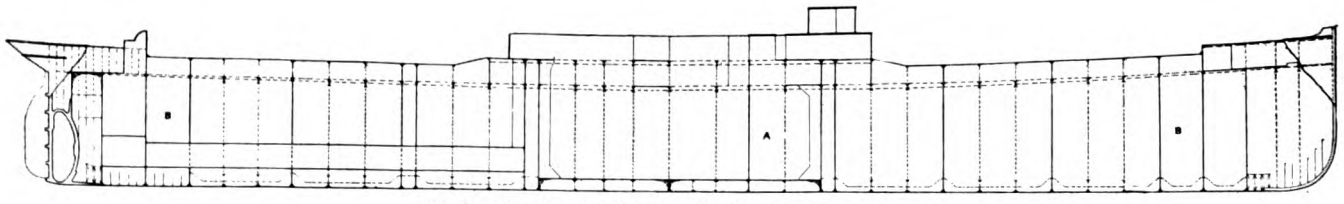

FIG. 2.—INBOARD PROFILE OF THE OIL TANKER PAUL PAIX.

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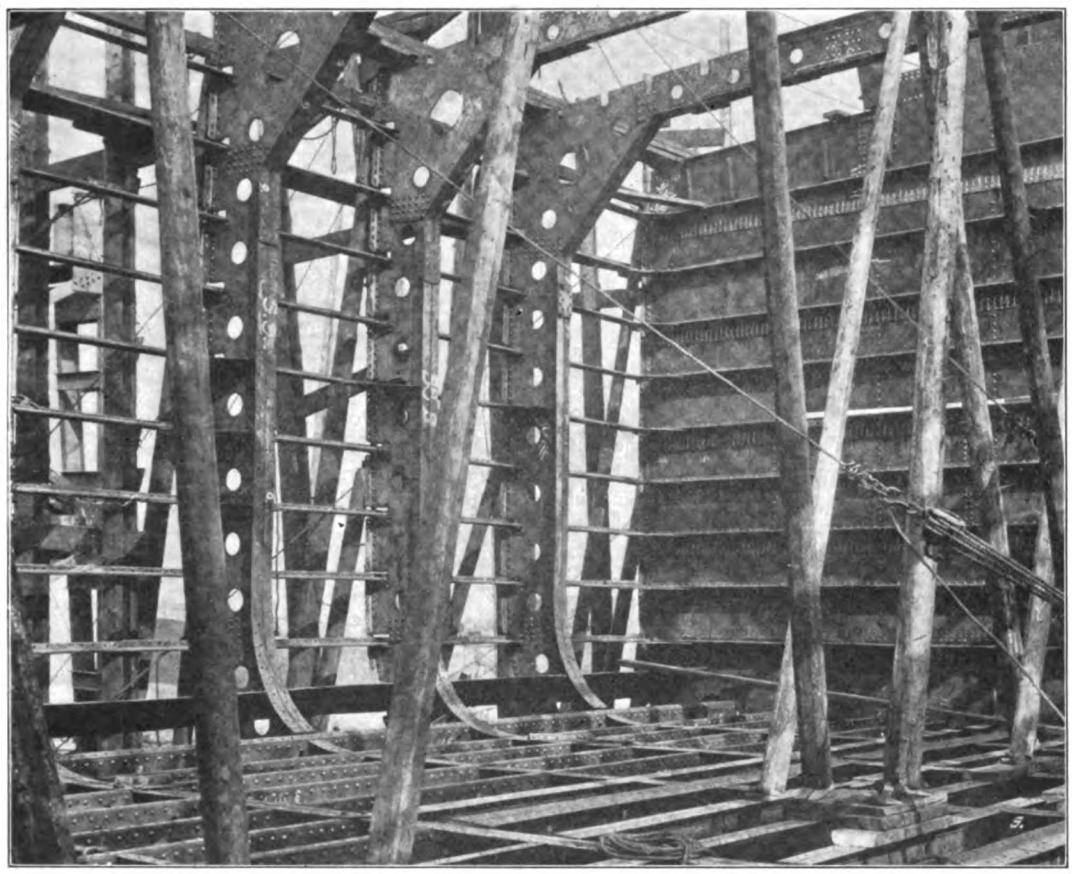

FIG. 3.—FRAMING OF THE PAUL PAIX.

bottom. The tank abaft the engine room is for carrying part cargo of refined spirit and is fitted with a cofferdam at each end. The short tanks at the ends of the vessel (B, B, in Fig. 2) provide for taking a cargo of spirit when more capacity is required than for carrying heavy oils, or these tanks may be used as supplementary tanks for special uses.

The main oil tanks are 30 feet long, and two transverses are fitted in each of these tanks. The transverses are 35 inches deep at the side, 20 inches across the deck, 39 inches at the bottom and 33 inches at the center-line bulkhead. They are formed of 18-pound plates and are connected to the shell plating by double angles. Double-faced angles are fitted 5 x 4 x ½ inches. In the engine and boiler space, practically the same spacing of transverses is maintained. In way of the

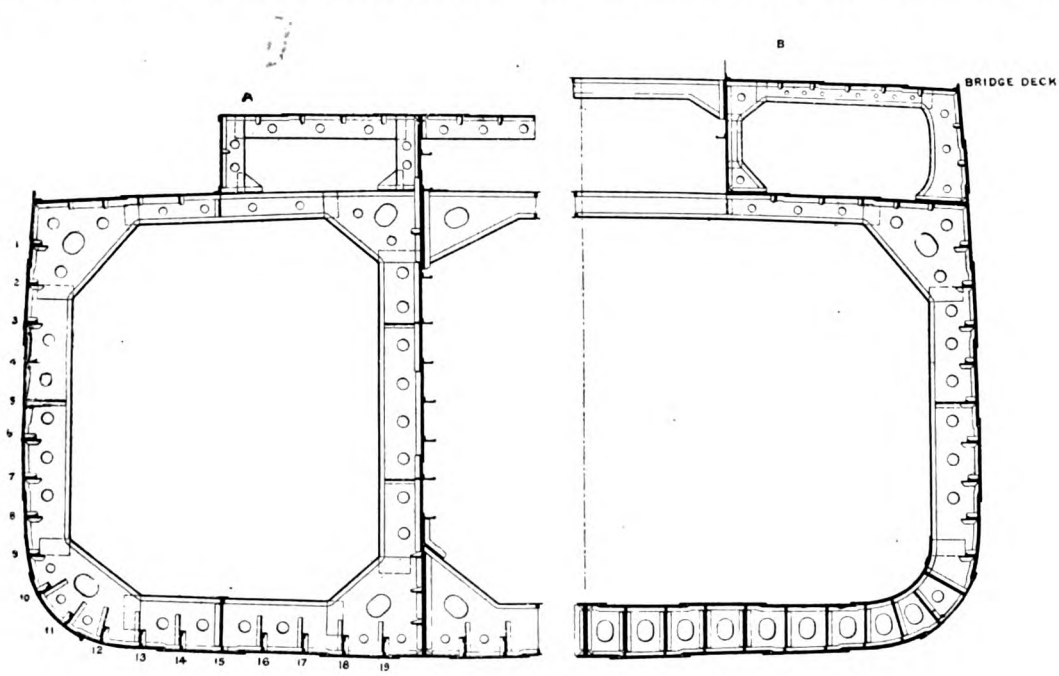

FIG. 4.—MIDSHIP SECTION OF THE PAUL PAIX.

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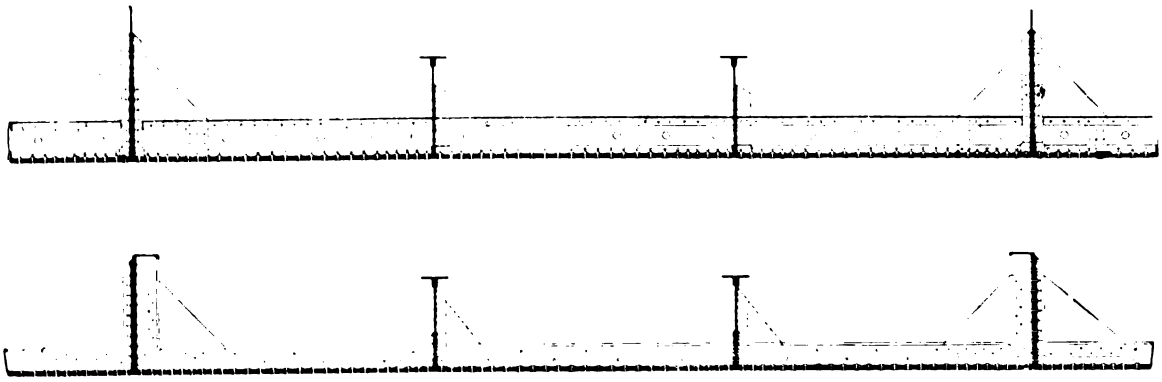

FIG. 5.—LONGITUDINALS.

double bottom the alternate transverses are fitted continuously around the bottom to the center line, and the longitudinal girders are fitted in long lengths between these transverses, to which they are efficiently attached. The remaining transverses are stopped at the deep girder in the double bottom next the margin plate, and are then fitted intercostally between the longitudinals to the center line. The margin plate is fitted intercostally between the transverses and connected to them by double-riveted water-tight collars.

The uppermost bulb angle (longitudinal) below the upper deck (No. 1, in Fig. 4) is 8 x 3½ x 13/32 inches amidships, and is reduced to 7 x 3½ x 13/32 inches at the ends; the lowest bulb angle (No. 9) is 9½ x 3½ x 19/32 inches, and the intermediate bulb angles are graduated in size according to the depth of immersion. They are spaced 29 inches apart. The bottom longitudinals are 15 inches by 16 to 14 pounds, graduating in depth to 12 inches at the upper turn of the bilge; the

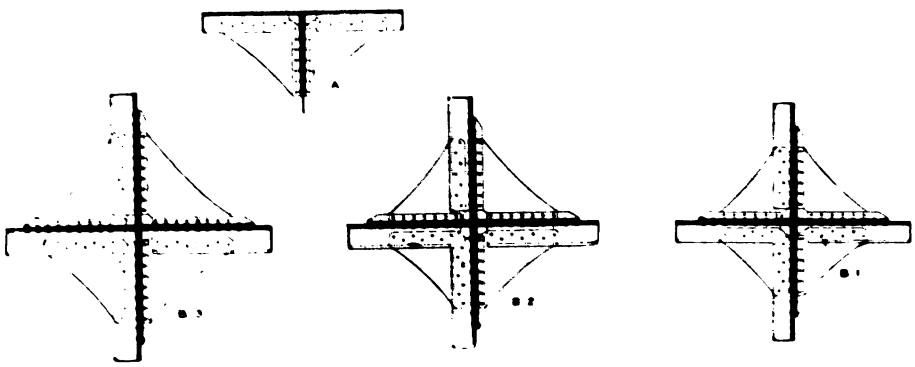

FIG. 6.—DETAILS OF CONNECTION TO STRINGERS AND BULKHEADS.

angles at the top and bottom of these girders are 3½ x 3½ x 13/32 inches. The deck longitudinals are 7 x 3 x 13/32 inches amidships, except in way of the bridge, where they are 5½ x 3 x 13/32 inches and they are also this size at the ends of the vessel. They are spaced about 27 inches apart. The longitudinal materials at the upper and lower parts of the structure for about the amidship half length are increased in

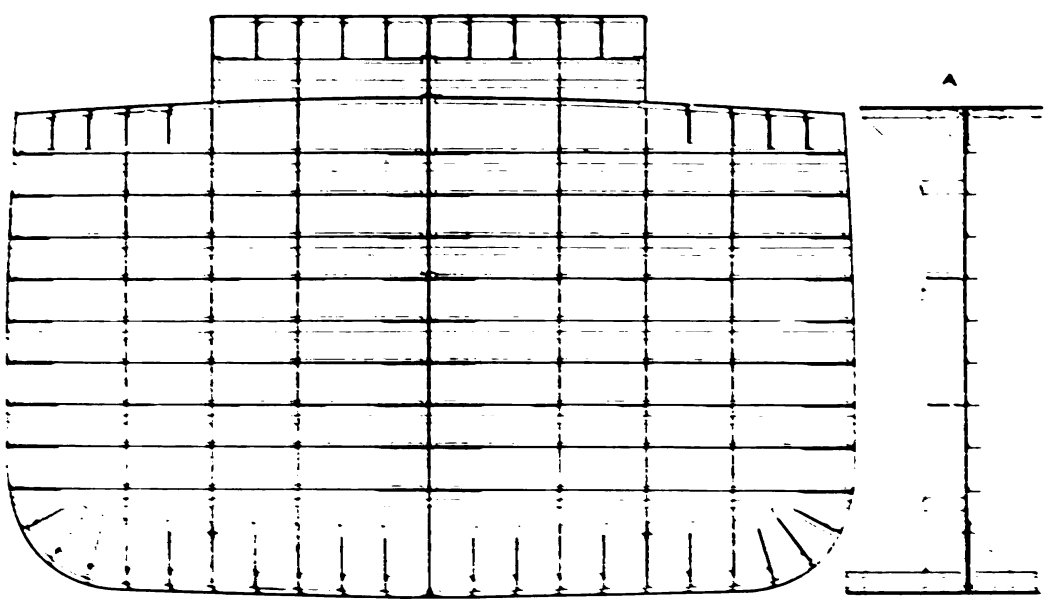

FIG. 7.—[illegible]

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strength beyond that required to resist the water pressure, because these parts are also subject to bending stresses. The trunk deck longitudinals at the sides of the hatchways are 7 x 3 x 11/32 inches bulb angles; those in between the hatchways are reduced to 5½ inches.

The upper deck and trunk sides are of 20-pound plate, the upper deck stringer plate is from 24 to 18 pounds clear of bridge and 20 pounds in the bridge. The stringer plate at the bridge ends is 32 pounds. The trunk stringer plate and trunk deck center plate are 20 pounds. The sheer strake is 24 pounds in way of the bridge, 32 pounds at the bridge ends and 18 pounds at the ends of the vessel; the side plating is from 22 to 18 pounds, and 24 to 18 pounds alternately, and the bottom plating is 26 pounds amidships, 18 pounds in the fore peak and 20 pounds aft. The bridge side strakes of plating are 18 and 16 pounds respectively. Three strakes of plating at each side of the keel plate have their midship thicknesses maintained to the collision bulkhead, and the flat part of the bottom from No. 4 bulkhead (numbering from forward) to the collision bulkhead is additionally strengthened by fitting double 6 by 6-inch angles to the transverses and double angles 3½ by 3½ inches to the longitudinals.

The plate edges up to the strake below the sheer strake are parallel to the keel, and the spacing of the longitudinals at the ends of the vessel does not exceed the midship spacing, but is in some parts closer than amidships. The longitudinals are also so arranged that the crossing of the plate edges is almost avoided. The uppermost longitudinal on the middle-line bulkhead in the trunk is a 7 x 3 x 11/32-inch bulb angle, and the bottom longitudinal is 9½ x 3½ x 9/16 inches, the intermediate stiffeners being graduated in size. The transverse bulkheads (Fig. 7) are supported on one side by three-deep web plates A on each side of the middle line bulkhead and on the opposite side with horizontal stiffeners in line with the longitudinals on the side plating and the longitudinals on the center-line bulkhead. The sizes of these horizontal stiffeners are graduated according to their depth of immersion in a similar manner to those at the sides of the vessel and on the center-line bulkhead. The longitudinal frames and beams and longitudinal stiffeners on the center-line bulkhead are cut at the transverse bulkheads, and are fitted with brackets efficiently connected to the stiffeners and bulkheads.

The Telephone Equipment of the Lusitania.

Of the many new features which go to make the Cunarder *Lusitania* and her sister ship the *Mauretania* the most up-to-date passenger steamships afloat (in their facilities for promoting comfort for their passengers and facilitating good service), the private branch telephone equipment is highly important. We believe this to be the first instance where a complete private branch exchange, giving regular exchange facilities, has been installed on an ocean-going liner. This apparatus was specially designed by the engineering department of the Western Electric Company to meet the requirements peculiar to such an installation.

The equipment consists of a switchboard having a capacity of 200 stations, 89 of which are now in use, and 20 exchange lines, 10 of which are in use when the vessel is in port. The switchboard and the exchange apparatus is located amidships in a room set apart for that purpose. The switchboard is of special design, the power panel for controlling the ringing generators being placed on top of the switchboard proper. This power panel is used for charging and discharging the batteries and has mounted on it the necessary switches and measuring instruments.

The telephones used are of special design and construction, as shown in Fig. 1. The body is of metal, gilded or silvered to harmonize with the furnishings and general color scheme of the room decoration in which it is used. The bell, induction coil and condenser are mounted in a neat box having a white enameled cover. In most cases these bell boxes are completely out of sight and the wiring between them and the instruments is run behind the paneling of the cabins. The switchhook is designed to grip the receiver and prevent the latter from falling down or knocking against the side of the instrument when the ship rolls. That part of the switch hook

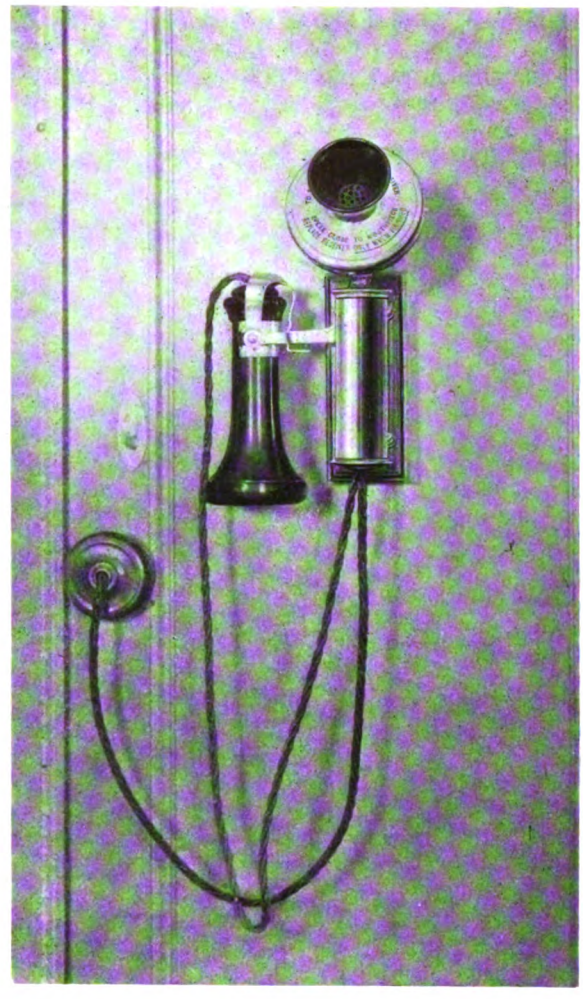

FIG. 1.—TELEPHONE INSTRUMENT, SHOWING SPECIAL CLIP FOR HOLDING RECEIVER.

which holds the receiver is also pivoted horizontally so that the receiver may swing with the ship and always tend to maintain the active length of the lever. If this provision were not made the swing of the ship would lift the lever, owing to the shortening of the distance between the center of gravity of the receiver and the fulcrum of the lever. This arrangement has proved highly satisfactory and its use will doubtless become universal for this class of service.

The telephones used on this liner are installed in the regal and suite staterooms, in the cabins of the purser, the ship's doctor, the chief steward and in the information bureau. This enables the passengers to communicate with any of these departments without leaving their rooms. The hundred and one little things that come up during a voyage can be quickly arranged with the least possible trouble to the passenger. Passengers in different parts of the ship can communicate with each other, and all the advantages of a telephone on land are possible here.

For further convenience of the passenger a system has been

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arranged by which he can communicate with those on shore right up to the time the ship leaves her dock. This is accomplished by connecting the ship's exchange with that of the city. Ten pairs of wires for the exchange junction lines are carried in a lead-covered cable from the switchboard to each side of the ship, where they are terminated in a box of special design. On the landing stage or dock where the ship is berthed a series of similar boxes is arranged, each having ten junction lines from the city exchange terminating in them. These boxes are so placed that in whatever position the ship is berthed one of them will be in easy reach of the box on the ship. A length of flexible cable containing ten pairs of lines and fitted at each end with a special cable head is provided for effecting connection between the ship's box and the

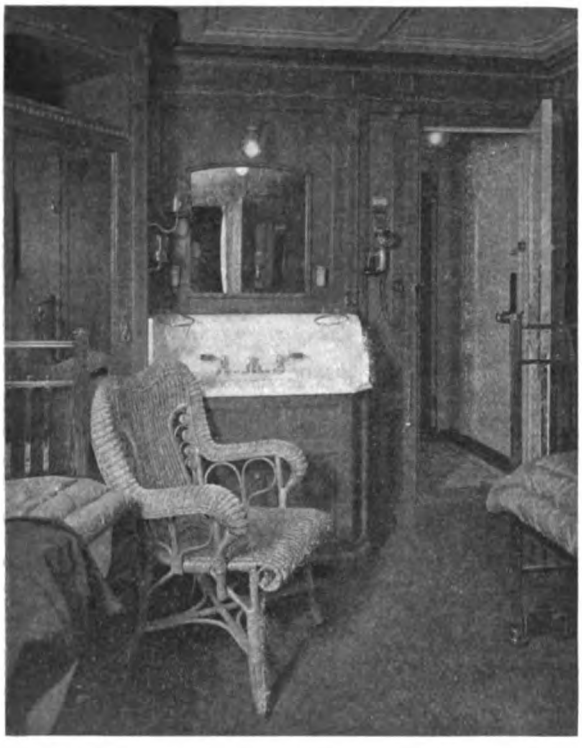

FIG. 2.—STATEROOM, SHOWING TELEPHONE INSTRUMENT.

shore box. At the Liverpool landing stage three of these shore boxes are provided and similar ones are to be provided in New York.

The telephone system also greatly aids in the actual working of the ship. On the bridge there are two pillar 'phones, which enable the officer on watch to speak to the steering gear compartment, the engine room, the starting platform, the after bridge, the forecastle and the crow's nest. When the officer on watch receives the information from the lookout in the crow's nest, he immediately calls up the engine-room platform. From the engine-room platform communication can be had with the chief engineer's offce, the steering-gear compartment, the pump rooms and the dynamo rooms. Communication is also afforded between the captains, officers, stewards, pursers, the Marconi house and the information bureau.

The chief steward uses the telephone to order from the various store rooms whatever may be required for the bill of fare, as well as to give instructions to his assistants regarding their duties. The purser and those of this department use the telephone almost continuously, while the information bureau is always busy.

From this it is seen that the principal officers of this vessel, whether the navigators, engineers or administrative officials, find immediate use for the telephone. In fact, in a vessel like the *Lusitania,* where the passengers and crew number over 3,000, a telephone system becomes a necessity. The results obtained from the use of this system on the *Lusitania* have been so satisfactory that it is only a question of time before all our big liners will be similarly equipped.

Magnetic Survey Yacht Carnegie.

The Carnegie Institution of Washington has recently placed a contract with the Tebo Yacht Basin Company, of Brooklyn, N. Y., for the construction of a magnetic survey yacht, to be built after designs by Mr. Henry J. Gielow, of New York. This boat is unique in that all the materials entering into its construction are to be non-magnetic, a fact which prohibits the use of iron and steel in the construction of all the machinery and fittings. The motive power, which is to consist of producer gas, further prohibits the use of copper and brass in the gas producer and parts of the engine in contact with the gas. Bronze, manganese metal and gunmetal will be largely used in the construction of the machinery.

The principal dimensions are: Length over all, 155 feet 6 inches; length on load waterline, 128 feet 4 inches; beam molded, 33 feet; depth of hold, 12 feet 9 inches; with a mean draft of 12 feet 7 inches, and a displacement of 568 tons with all stores and equipment on board.

The hull will be constructed of wood; the keel, stem, sternpost, frames and deadwood to be of white oak; the beams and planking of yellow pine, and the deck of Oregon pine. The fastenings to be locust tree nails, copper and Tobin bronze bolts and composition spikes. All deck fittings, metal work on spars and rigging will be of bronze and copper, and the rigging will be of hemp.

The vessel will have full sail power, being rigged as a hermaphrodite brig, carrying just under 12,900 square feet of plain sail. In addition to this there will be an auxiliary power plant consisting of a six-cylinder, internal combustion engine capable of developing 125 indicated horsepower at 350 revolutions per minute, which, driving a feathering propeller of special design, will give the vessel a speed of six knots in calm weather. The engine will be operated by gas generated in a producer gas plant. The vessel will carry 25 tons of coal in her bunkers, which will give her a cruising radius of 2,000 nautical miles at a speed of six knots.

The living quarters are all below; ventilation and lighting being obtained by means of a cabin trunk on deck about 42 feet 8 inches in length, 16 feet 6 inches in width and 3 feet in height, and safety will be secured by means of six transverse watertight bulkheads dividing the vessel into seven compartments. The officers' and crew's quarters will be forward, 42 feet in length, occupying the full width of vessel; next will be the quarters for the scientific staff 38 feet in length and extending the full width of the vessel; and abaft of this will be the machinery space, 23 feet in length. The living quarters have been planned to give good accommodations for all, and will be fitted with all necessary conveniences.

The observation room and observatories are located on the main deck amidships, and consist of a central observation room with circular observatories forward and aft of it. The observation room will be 14 feet 6 inches long and 16 feet wide, and the observatories will be circular, 7 feet 6 inches in diameter, each fitted with a revolving dome, constructed of bronze framework and plate glass. The joiner work will be in white pine painted, with hardwood trimmings finished bright.

The first voyage of the *Carnegie* will be to the North, visiting Hudson Bay and Greenland.

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Centrifugal Pump Fire Boats.

An abstract of a paper, read by Mr. Charles C. West before the Society of Naval Architects and Marine Engineers, describing the centrifugal pump fireboats recently built for Chicago, was published on page 539 of our December, 1908, issue. This paper included data taken on an eight-hour test on one of these boats, the results of which, as given in the advance copies of the paper, showed that 4,800 gallons of water were discharged per nozzle per minute. This figure was subsequently corrected when the paper was read to 4,808 gallons, making a total of 9,616 gallons per minute for the boat.

The steam consumption of the turbines per B. H. P. per hour was given in the paper as 18.4 pounds, and the coal consumption per B. H. P. per hour was 2.82 pounds. Since the trial was made, however, it was discovered that the impellers of the pumps had been fitted too closely, and were rubbing badly, so that it was necessary to take them out and give them more clearance. The figures given in the paper, as published, therefore, for the B. H. P. of the turbines are quite unreliable, and the actual B. H. P. was undoubtedly considerably more than the amount stated. How much more it is impossible to say, as there is no way, of course, to determine what the increased resistance in the pumps caused by this excessive friction of the impellers was. It may be stated, however, that all four sets for the two boats, that is, the turbines, generators and pumps, were thoroughly and carefully tested at the works of the General Electric Company, at Schenectady, before shipment to Manitowoc, and that the water consumption per B. H. P. was found to be 15.8 pounds, the efficiencies of the pumps varying from 70 to 75 percent. These results were obtained with a steam pressure of 160 pounds, a vacuum of 30 inches and with dry steam. The B. H. P. developed was 675. In the Manitowoc test, described in the paper, the moisture in the steam, determined by calorimeters, placed close to the turbine throttles, was 2.3 percent. Assuming that the steam consumption of the turbines went up to 16.25 pounds, which seems a fair allowance, the B. H. P. would have been about 1,325, the efficiency of the pumps about 67 percent, the B. H. P. per square foot of grate surface about 15.8, and the coal per B. H. P., with no deduction for the auxiliaries, about 2.5 pounds, corresponding to about 2.25 pounds per indicated horsepower. All these figures, it should be remembered, are the averages of fifteen-minute readings, extending over a full eight-hour period, including all the necessary cleaning of fires, with the same fire-room crew for the whole test.

Since then more clearance has been given the impellers, and the pumps have been put through the required four-hour test, running absolutely dry without the slightest trouble of any kind, and a subsequent examination of the impellers showed no sign of rubbing whatever.

The Harbor Tug Essayons.

A new type of harbor tug has just been completed by the Racine Boat Manufacturing Company for the United States government, to be used by the Engineers' Department on Lake Superior in the vicinity of Duluth. This boat was designed by government engineers primarily for use as an ice-breaker, for the purpose of clearing the canals in midwinter. She is 86 feet long over all, with a beam of 21 feet and a draft of 10 feet 6 inches. The hull is constructed entirely of steel with extra heavy frames, and with double plating at the bow for encountering heavy ice. The bow is sharply cut away under water, while the underbody amidships and aft is of comparatively large displacement, thus giving a form of hull which will allow the forward part of the boat to slide up on heavy ice and crush its way through.

The *Essayons* is propelled by a fore-and-aft compound engine, having cylinders 16 and 34 inches diameter, with a common piston stroke of 26 inches. Steam is furnished at a working pressure of 180 pounds per square inch by a fire-box boiler having 1,560 square feet of heating surface. The boat was designed for an average speed of 12 miles per hour, and is fitted with a steam steering gear. Heavy towing bits and Sampson posts are also provided at the bow and stern, as the tug is expected to prove herself of value for towing purposes.

The First Successful English Hydroplane.

Since experiments were first made with hydroplanes, interest has centered in the speeds which could be attained on given powers with this type of boat. The photograph shows a hydroplane 13 feet long with a beam of 5 feet 6 inches, equipped with a three-cylinder, 12-horsepower Brooke motor, which has already attained a speed of approximately 20

THE SURPRISE AT FULL SPEED.

statute miles per hour. This boat was built by J. W. Brooke & Company, Ltd., Lowestoft, who claim that she is the first successful English hydroplane to be built. She is equipped with a solid propeller fixed well below the surface of the water, which is driven by the motor through a universal joint. Trials are now being carried out with different propellers, and it is expected that, as soon as the most efficient propeller is found, the speed already attained will be increased.

THE DEVELOPMENT AND PRESENT STATUS OF THE EXPERIMENTAL MODEL-TOWING BASIN.

BY H. A. EVERETT, S. B.

In probably no branch of naval architecture or marine engineering do scientific observation and deduction play such an important part as in the modern model-towing basin. What the research laboratory is to the advanced chemist and physicist, this becomes to the present-day shipbuilder, so before proceeding with a description of the existing tanks and their operation, it will be of interest to review the steps leading up to the establishment of the pioneer tank of Wm. Froude, in 1872.

Over two centuries ago, scientists interested themselves in the resistance a floating body offers to forward movement, and theories and opinions concerning the form necessary for least resistance were advanced by such men as Newton, Bernouilli and Euler, which were fortified, in many cases, by formidable mathematical work. Their results, however, were so slightly confirmed by practical experiments that they were of little value. In 1770 the French Academy of Sciences organized a commission for resistance investigation, consisting of D'Alembert, Condorcet and Bossut, who were to collaborate with Borda in deducing from his experiments (of 1763-'67) and others a mathematical formula which should give a form of least resistance, and it is here that we strike the keynote of the fallacy that apparently ran through all the

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work up to Froude's time, namely, the belief that a *single* form existed which offered *least* resistance under *all* conditinons of speed, displacement, and length. To us at present this seems hardly conceivable, and yet traces of it appear, even to-day, in the experiments sometimes carried out. Borda's experiments included some ship-shaped solids, but were mostly concerned with mathematical solids, as prisms, cylinders, etc., and along a similar line the French vice-admiral, Thevenard, worked at Lorient. Later (1775-'94) the Swedish chief constructor, Chapman, attempted to find out the influence of the location of the maximum section in solids of rotation with parabolic or conical ends, but the solids were small (28 inches long) and his results did little to advance the cause.

Col. Marc Beaufoy carried out experiments in England about this time (1793-'98), which may be considered to be the beginning of the present method of attacking the problem. He towed a large number of solids, some submerged and some floating, in the Greenland dock. A run of 400 feet was obtained, and the water had a depth of 11 feet. The models were drawn by a heavy weight suspended from three large sheer legs forming a tripod nearly 60 feet high. (See Fig. 1.) The absolute motion of this was multiplied by pulleys, and the time and speed automatically recorded on a batten by a pendulum. The experiments were originally undertaken in 1791 at the instigation of the "Society for the Improvement of Naval Architecture" (now out of existence), which furnished some financial backing, but were completed by Col. Beaufoy from his own resources. The models used were largely geometrical, though some approximated ships' forms, but the value of his work was in his segregation of the frictional resistance and the study and analysis he made of it. He carried out experiments for this upon planks of varying lengths and tabulated the frictional resistances. The models were of wood, painted.

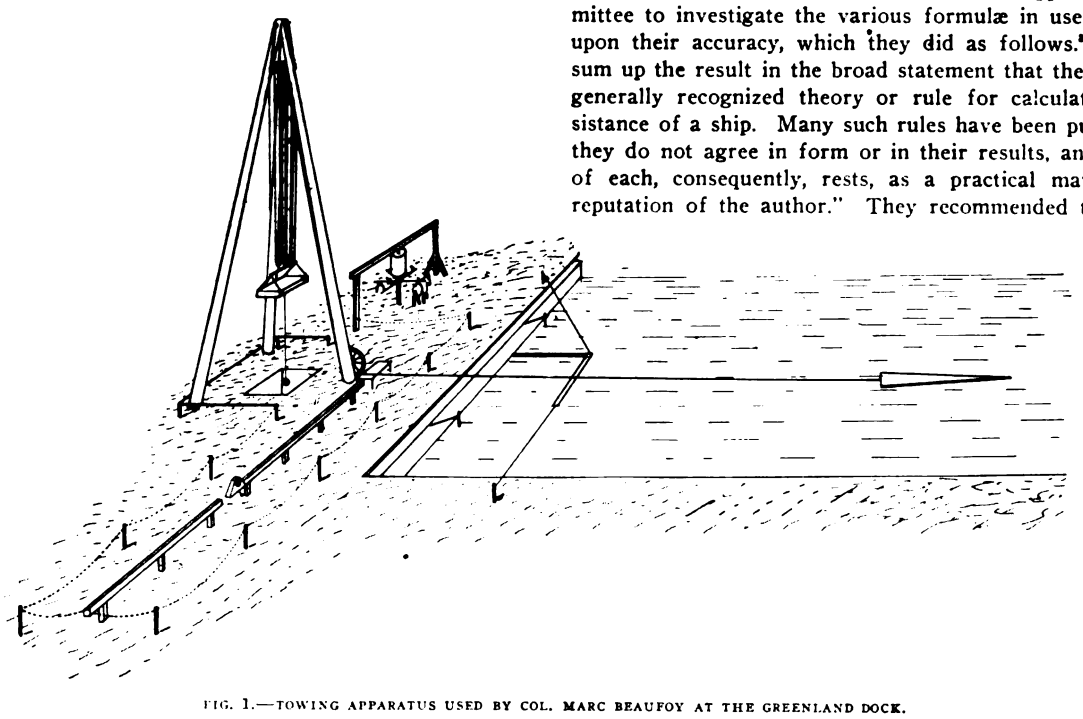

FIG. 1.—TOWING APPARATUS USED BY COL. MARC BEAUFOY AT THE GREENLAND DOCK.

The interest in experimental work along this line seems to have flagged about the last of the eighteenth century, and though numerous scientific discussions appeared, little additional research work was attempted until the middle of the nineteenth century, when steam, as a motive power, made its appearance, and it became imperative to have information regarding the power necessary to obtain a certain speed in order to build engines in accordance. This brought forth additional experiments, which were in the direction of towing tests[1] of actual steamers.

From the results of these towing tests and what trial-trip data were available, many formulæ for power were advanced by the authorities[2] of that time, all of which were largely empirical. Based as they were, on tests of vessels not modern, even at that time, and many upon sailing ships, they depended so largely upon the personal knowledge and experience of the user that they were of little value outside of the originators' hands, and even there, within but narrow limits.

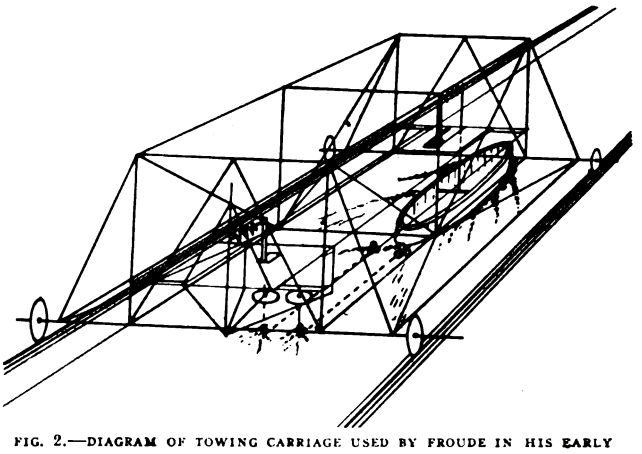

FIG. 2.—DIAGRAM OF TOWING CARRIAGE USED BY FROUDE IN HIS EARLY EXPERIMENTS AT CHELSTON CROSS, TORQUAY.

About this time the British Association appointed a committee to investigate the various formulæ in use, and report upon their accuracy, which they did as follows.[3] "We may sum up the result in the broad statement that there exists no generally recognized theory or rule for calculating the resistance of a ship. Many such rules have been put forth, but they do not agree in form or in their results, and the credit of each, consequently, rests, as a practical matter, on the reputation of the author." They recommended the carrying out of more towing experiments on full-sized ships, Froude dissenting.

Up to this time the resistance not due to friction, when dif-

[1] Towing experiments were carried out by Dupuy de Lome & Jaffe and Admiral Bourgois upon the following vessels: 1840, *Sphinx* (wooden steamer); 1846, *Pursuin* (schooner); 1848, *Fabert* (brig); 1853, *Morceau* (wooden frigate); 1856, *Duperre* (battleship); 1861, *Elorn* (frigate).

[2] Tredgold, Campaignac, Bourgois, Dupuy de Lome, Nystrom, Thorneycroft, Guide & Jay, Isherwood, etc.

[3] Merrifield, "First Report of the Committee of the British Association, Exeter meeting, 1869."

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ferentiated at all, had been assumed to be a direct displacement resistance, that is, the resistance was assumed to have a relation to the actual quantity of water (equal to the displacement) which the ship moved aside in passing, and it remained for Scott Russel to bring forth the theory of wave-making resistance as a distinct and separable factor. Professor Rankine, in 1866, published his stream-line theory.

The modern attack began with the resumption of towing experiments upon *ship* models by William Froude[4] about 1870. He was a member of the before-mentioned committee of the British Association, and, in an appendix to their report, made the proposal to carry out towing experiments upon models. He held that from *accurately* carried-out experiments upon *carefully* made ships' models, results would be obtained which would permit making a perfectly definite and correct estimate of the power necessary to drive the full-sized ship, represented by the model, at speeds *corresponding* to those at which the model was towed. He objected to the resumption of towing experiments upon full-sized ships, on the grounds that the large number of types that must be taken and the expense in time and money to carry them out made it impracticable. Acting upon the suggestion of Sir E. J. Reed, he drew up a proposal and estimate for an experimental station. This was accepted, and the first real model-towing basin was constructed at Chelston Cross, Torquay, near his home. This was not, by any means, an elaborate structure, for it is very doubtful if anyone at that time looked upon it as more than a temporary structure, which would be done away with when the experiments should be finished. It was simple and complete, and in the hands of a master like Froude, it turned out wonderful work. In fact it has served as a pattern for all later tanks.

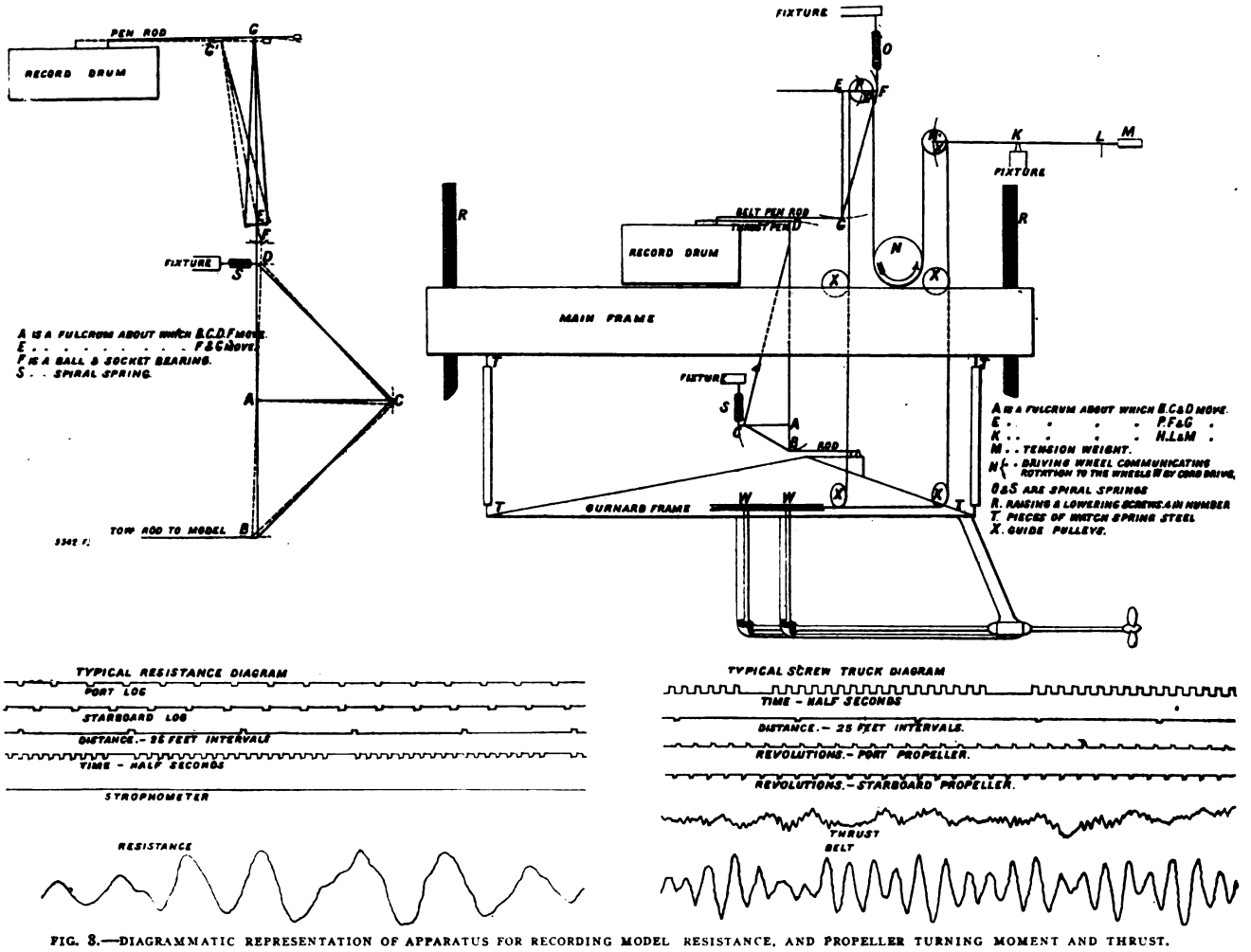
PEN ROD
RECORD DRUM
FIXTURE
TOW ROD TO MODEL
A IS A FULCRUM ABOUT WHICH B.C.D.F MOVE.
E . . . . . F & G MOVE.
F IS A BALL & SOCKET BEARING.
S . . SPIRAL SPRING.
FIXTURE
BELT PEN ROD
RECORD DRUM
MAIN FRAME
GURNARD FRAME
ROD
A IS A FULCRUM ABOUT WHICH B.C.& D MOVE.
E . . . . . P.F.& G .
K . . . . . H.L.& M .
M . . TENSION WEIGHT.
N & . DRIVING WHEEL COMMUNICATING ROTATION TO THE WHEELS W BY CORD DRIVE.
O & S ARE SPIRAL SPRINGS
R. RAISING & LOWERING SCREWS AS IN NUMBER
T. PIECES OF WATCH SPRING STEEL
X. GUIDE PULLEYS.
TYPICAL RESISTANCE DIAGRAM
PORT LOG
STARBOARD LOG
DISTANCE.- 25 FEET INTERVALS
TIME - HALF SECONDS
STROPHOMETER
RESISTANCE
TYPICAL SCREW TRUCK DIAGRAM
TIME - HALF SECONDS
DISTANCE.- 25 FEET INTERVALS.
REVOLUTIONS.- PORT PROPELLER.
REVOLUTIONS.- STARBOARD PROPELLER.
THRUST
BELT

FIG. 8.—DIAGRAMMATIC REPRESENTATION OF APPARATUS FOR RECORDING MODEL RESISTANCE, AND PROPELLER TURNING MOMENT AND THRUST.

Froude was a practical mathematician and his principal service to the world lies more in the careful analysis he made of his towing experiments and his development and presentation of his "Laws of Comparison," whereby the results obtained upon models could be enlarged to the scale of the full-sized ship than in the equipment of this first tank. The tank itself was 300 feet long by 36 feet wide by 10 feet deep. The sides were sloping and of asphalted earth, and the light wooden carriage running on tracks suspended from the roof was drawn by a stationary engine at one end of the tank.

On the completion of the tank, Froude immediately began his experiments. Considerable divergence of opinion existed as to the reliability of tank experiments, and Mr. Scott-Russell, while admitting the value of *comparative* experiments upon different models, said that in his opinion experiments with small models were "quite remote from any practical results on a large scale,"[5] but he reckoned without his host, for Froude, acting for the Admiralty, carried out his famous

[4] Wm. Froude was a civil engineer by profession, and was associated with Mr. Brunel in many of his railway problems, retiring in 1846. When Mr. Brunel was superintending the building of the *Great Eastern* he requested Mr. Froude to carry out experiments on friction for her launching (1869). Later, Froude investigated the rolling of ships and built the foundation of the present theory of waves. In 1869 he was appointed one of a committee of six of the British Association, as above stated, to report on "The State of Existing Knowledge on the Stability, Propulsion and Seagoing Qualities of Ships, and as to the application it is desirable to make to Her Majesty's Government on these subjects."

[5] Trans. Inst. N. A., 1870. Vol. XI., p. 82.

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"Greyhound" experiments.[6] The *Greyhound* was a screw sloop of 878 nominal tonnage without masts, and this ship Froude towed from a 45-foot boom, rigged out over the starboard side of H. M. S. *Active* at varying speeds and displacements. He took three displacements, and at each three different trims; in each condition she was tried at speeds ranging from 3 to 12½ knots. Upon the curve of resistance on speed which he obtained from these experiments, he superposed the curve which he obtained from towing a model of the *Greyhound* (1/16 the actual size) under each of the different conditions to which the ship herself had been subjected. The curve obtained from the model experiments practically coincided with that obtained from the towing of the ship herself, a splendid confirmation of his faith in model experiments, and from that time *carefully* carried out experiments upon the *exact model* of the proposed ship have given us the surest estimate of the power to be required.

Froude's vindication of his theories was so complete that towing experiments were resumed with renewed vigor, closely following, however, the lines laid down by him. The Dutch Naval Constructor Tideman equipped a tank similar to that of Froude in one of the Royal Docks of Amsterdam and towed paraffine models up to 30 feet in length. His work on frictional resistance of model and ship surfaces is standard to-day. (Memoriaal van de Marine, Amsterdam, 1786.)

France undertook similar work at Brest, when Risbec inaugurated the towing of wooden ship models covered with tinfoil, but modified Froude's method to the extent of towing models from a floating platform, which was itself towed.

In Italy the work of Lettieri along the same line was undertaken in a dock with the towing apparatus stationary on shore, after the order of Beaufoy's.

Froude's method of carrying out his model experiments, as well as his machinery therefor, has been copied practically in its entirety by the subsequent establishments, except for minor changes and improvements, and a description of one, in a general way, will apply to nearly all. The model carefully constructed, as described later, to the exact form

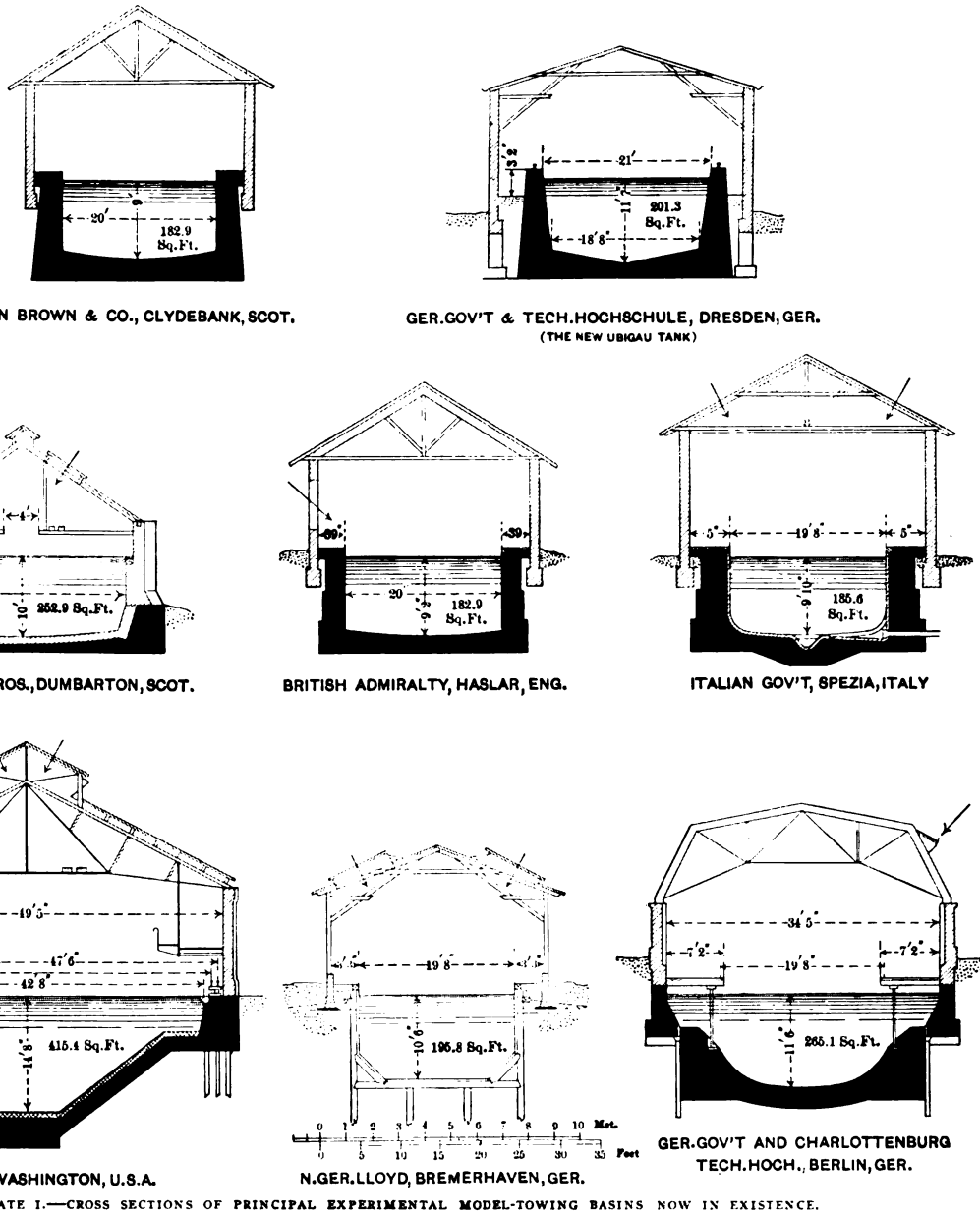

PLATE I.—CROSS SECTIONS OF PRINCIPAL EXPERIMENTAL MODEL-TOWING BASINS NOW IN EXISTENCE.

[6] Trans. Inst. N. A., 1874, p. 59. Discussion by Wm. Froude, of *Greyhound* experiments. "The experiments with the ship, when compared with those tried with her model, substantially verify the law of comparison which has been propounded by me as governing the relation between the resistance of ships and their models. This justifies the reliance I have placed on the method of investigating the effects of variation of form by trials with varied models; a method which, if trustworthy, is equally serviceable for testing abstract formulæ as for feeling the way towards perfection by a strictly inductive process."

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of the ship, is towed at various speeds from a carriage spanning the tank, and its resistance, trim and speed automatically and continuously recorded on apparatus located on the towing carriage. There is also propeller apparatus on the carriage for recording the revolutions, turning-moment speed, and thrust of the model propellers. The model is usually towed both with and without the propellers in place behind it. Figs. 2 and 3 show the carriage, and, diagrammatically, both the model and propeller apparatus, with typical diagrams, as installed in one of the most recent tanks. (John Brown & Co., Ltd., Clydebank.) As the speed through the water may not be the same as the speed of the carriage on account of currents in the tank, a measure of these currents is made by the revolutions of two log screws running in advance of the model, and a graphic measure of speed from a strophometer is recorded for detecting any lack of uniformity of speed.

William Froude also carried out experiments upon the frictional resistance of planes of different surfaces from 2 to 50 feet in length, which form the basis of our present-day estimate of skin resistance of ships. Upon his death, in 1879, his son, R. E. Froude, who had been his assistant, was appointed by the Admiralty to carry on the work, and a new tank was constructed at Haslar, England.

Meanwhile, Mr. Wm. Denny, of the Clyde shipbuilding firm of Wm. Denny & Bros., had been so impressed with the value of tank experiments that his firm had built a private establishment in 1884 very similar to that at Torquay, and inaugurated the custom of towing models of all ships built by them. This firm built many paddle-wheel steamers, some of them of very high speed, and in these the location of the paddle wheels to take advantage of the wave formation thrown up by the ship was one of the points readily solved by tank experiments. It placed them in a position to guarantee speed and to take the position of pre-eminence that they did for this type of boat. Following is a list of the tanks at present in existence, and Plates I. and II. give a general idea of the arrangement of each:

PRINCIPAL EXISTING MODEL—TOWING BASINS.

Date	Owner	Place	Length	Breadth	Depth	Run	Section
1884	W. Denny & Bros....	Dumbarton, Scot....	200	22	10	250	
1886	Brit. Admiralty.....	Haslar, Eng.....	400	20	9	360	
1889	Italian Gov't.....	Spezia, Italy.....	538	19.7	9.9	480	
*1892	"Kette" S. B. Co. (old Uebigau tank).	Uebigau, near Dresden, Ger..	206	24.6	4.5	206	
1893	Russian Gov't.....	St. Petersburg.....	441	21.8	11	374	
1899	U. S. Gov't.....	Washington, U.S.A..	470	42.7	14.7	384	
1900	Cornell Univ.....	Ithaca, N. Y.,U.S.A.	418	16	10	418	
1900	N. Ger. Lloyd S.S. Co.....	Bremerhaven, Ger...	541	19.7	10.5	476	
1902	Tech. Hochschule & Ger. Gov't.....	Berlin, Ger.....	557.7	34.4	11.5	479	
1903	John Brown & Co...	Clydebank, near Glasgow, Scot ...	445	20	9	400	
1904	Tech. Hochschule & Saxon Gov't (new Uebigau tank)....	Uebigau, near Dresden, Ger.....	312	21.0	11.3	288	
1906	Univ. of Mich.....	Ann Arbor, Mich, U. S. A.....	300	22	10	275	
1906	French Gov't.....	Paris.....	525	32.8	13.1	442	
1907	Mitsubishi S. B. Co.	Nagasaki, Japan...					

NOTE.—The length, breadth and depth are the overall distances at the water surface and the depth is at the center line. The run is the length, exclusive of the docks, etc., at each end and the date is that of beginning experimental work.
* Now discontinued.

(To be continued.)

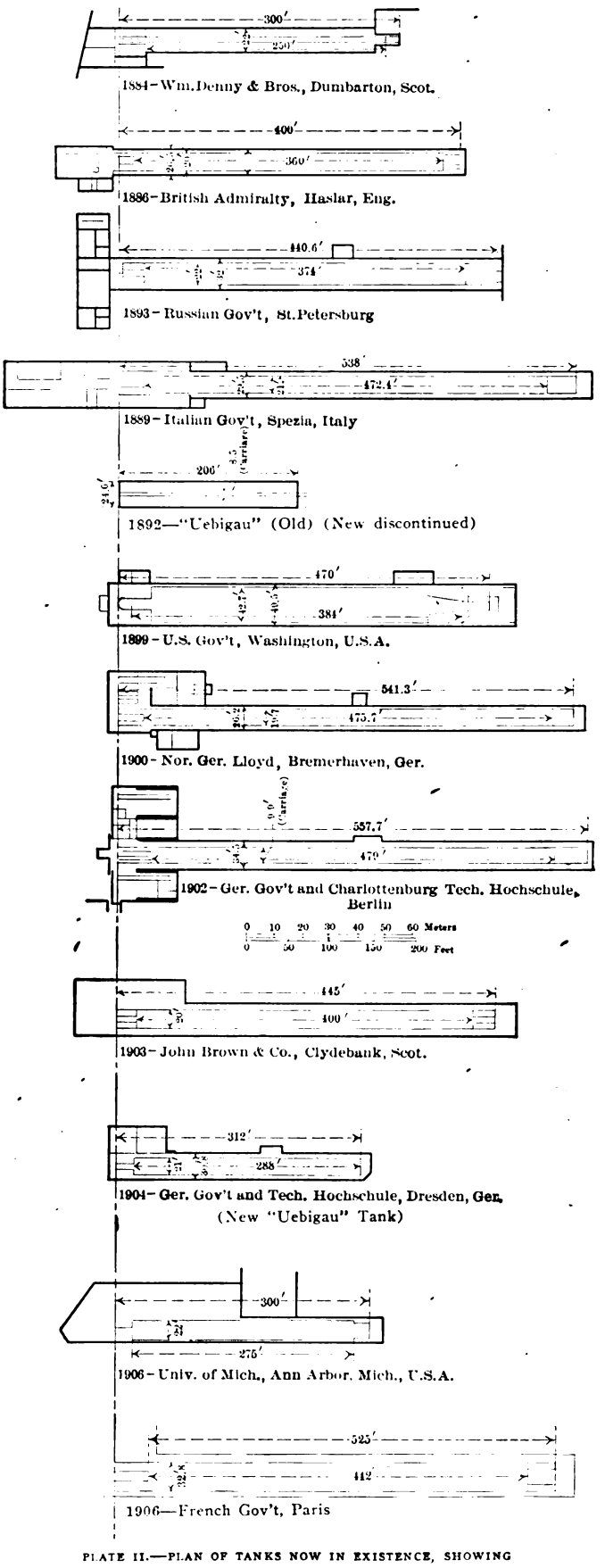

PLATE II.—PLAN OF TANKS NOW IN EXISTENCE, SHOWING PRINCIPAL DIMENSIONS.

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Government versus Private Work.

The controversy over the relative merits of naval work done in government establishments and in private shipyards is of long standing. One of the things which has always counted heavily against the government establishment is the lack of engineers sufficiently well trained in certain specialized lines. This is true in both the United States and England. In both countries most of the machinery for naval vessels is obtained from contractors, and, in the case of recent ships propelled by turbines, this work has been done by certain concerns which have secured the services of highly skilled and specially trained men who are thoroughly acquainted with the design, construction and operation of steam turbines. Since nearly all of the repair work, however, is carried out in government dockyards or navy yards, this machinery passes at once under the supervision of men whose knowledge of engineering is, on the whole, of a more general nature than that of the men employed by the builders. The results, as set forth by one of our correspondents this month, need little comment.

In the United States the work of designing naval machinery, the general supervision over repairs to naval machinery, the examination and supervision of machinery plans in detail submitted by contractors engaged in building government vessels, and the collection and arrangement of engineering data of the world's progress in naval engineering, are done at the Bureau of Steam Engineering, under the supervision and direction of line officers detailed for engineering duty only. The need is now being acutely felt for a greater number of younger officers adequately trained for this service. Undoubtedly the greatest efficiency results when the officers who design naval machinery are also the ones who superintend its construction on shore, and, later, its operation at sea; for only in this way can they acquire familiarity with all the needs of the service.

The opportunities which a young line officer has for instruction and development under such close association with engineering work in the navy are exceptional. In navy yards the engineering work of such officers includes the making of estimates for repairs, deciding upon their necessity, preparing designs for alterations and repairs and supervising and conducting the work when authorized both on shore and on the ships. The field for instruction and development for a young line officer on duty at a private shipbuilding yard, supervising the inspection of machinery for vessels under construction, is one of the best, especially if such officers are detailed to those posts with a view to their assignment to the ships under construction after they are completed. By their close personal contact with the machinery during this construction and the final stages of its assembly on board the ship, and by their presence and observation during the preliminary and full-speed trials, they acquire a mass of information about the machinery and ship in general which makes their services of the greatest value to the government during the succeeding years in which the ship is in service. It is generally admitted by officers of the navy that whatever excellence is attained in the equipment of ordnance, propelling machinery, auxiliaries, electrical equipment, etc., is due very largely to the fact that the officers who inspected the materials and superintended the construction on shore were the same ones who afterwards at sea supervised their operation.

There is a vast field for improvement in the design and installation of naval machinery, and also in the administration of government establishments. The expense of repair work at navy yards is notoriously large compared with the expense of similar work carried out by contractors, and this can be reduced only by closer and better supervision of machinery details and greater economy in navy-yard management and administration. What little constructive work has been done in the United States navy yards has entailed considerably more expense and taken a greater length of time than similar work performed in private shipyards, the most notable case being the construction of the battleships *Connecticut* and *Louisiana*. The *Connecticut*, constructed in the Brooklyn Navy Yard, cost $390,280 (£80,340) more than the *Louisiana* and

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required four months longer in building. It sometimes happens, however, as in the case of one of the battleships now being built in England, that the constructive work is carried out with all possible speed at a dockyard, only to have the completion of the ship delayed by the non-delivery of her machinery and ordnance, due to labor troubles at the contractors' works; but that is a condition of affairs which seldom happens.

Perhaps it is not strange that the highest efficiency is not maintained in a navy yard or dockyard where the work done is of such a miscellaneous character, ranging, as it does, all the way from the manufacture of ships' stores to the construction of the ship itself, and the total product of any one thing is such a comparatively small amount. Good results would hardly be expected from a strictly commercial establishment under these conditions. However, the fact remains that, in general, naval work can be done by contractors more cheaply, more expeditiously, and more efficiently than in government establishments; and, until conditions are changed, contractors are likely to remain far in the lead. This is the fact which most vitally concerns the people whose money is being spent for this work, and for whom the work is being done.

Trade Papers in Europe.

At a recent meeting of the Technical Publicity Association in New York, President Redfield made a comprehensive statement regarding the status of trade papers in Europe. In general, foreign trade papers seem to be of little value to the average business man, principally on account of the poor editorial quality of the publications. It has been the case in America that nearly all successful trade papers have first created their own demand by the excellent editorial quality of the magazine, and have then proceeded to fill this demand until now the mission of the trade paper is a definite one and its place in the business world a definite place. Mr. Redfield stated that theoretically the proper paper for an American to advertise in is one which is printed and distributed in the country which he wishes to reach, but practically it seems likely that good trade papers printed in America and intelligently distributed abroad may be better mediums than the feeble efforts which are the rule rather than the exception abroad.

Due to the fact that INTERNATIONAL MARINE ENGINEERING covers a field which is world-wide, we have had ample opportunity to test the truth of the above statements. When, three years ago, the extent of our circulation in Great Britain and Ireland seemed to justify the publication of an English edition, we entered this field not only with the idea of being better able to serve the interests of our readers by presenting at first hand the conditions which prevail in foreign shipyards, and especially those of Great Britain, the greatest shipbuilding center in the world, but also with the expectation of finding a definite place in the English business world. The results have amply fulfilled our expectations, and to-day we have evidence that our magazine has found a definite place in the business world, not only in the two countries in which it is published, but all over the world, as testified by our large circulation in all countries where there are maritime interests. We have found that people all over the world look to the two great English-speaking nations not only for engineering data but also for the dissemination of engineering information, which, especially in America, is not jealously guarded as a trade secret.

Model Towing Tanks.

When the bulk of shipping was carried in sailing vessels the shipbuilder was not as vitally concerned with the question of the resistance which a floating body offers to forward movement as is the builder of iron steamships to-day. Early designs of sailing vessels were based on the results of practical experience at sea and it was the aim of the builder to secure the best sea-going and sailing qualities for his ship. The result of years of experience with all types of ships gave him all the information he needed on this score. Fast sailing ships were therefore the result of a process of gradual development rather than of the direct application of the principles of theoretical naval architecture. With the advent of the steamship, however, it became important to know how variations in the shape of the hull affected the resistance which the ship offered to propulsion through the water and also the exact relation between power and speed for any ship. It was soon recognized that these and various other similar problems could best be investigated by means of towing experiments on small models of the ship itself provided the results obtained from such tests could be applied to the full-sized ship. The connecting link between the theoretical and practical application of such experiments was offered by William Froude in the development and presentation of his "Laws of Comparison," whereby the results obtained upon models could be enlarged to the scale of the full-sized ship, and this, as pointed out by a writer elsewhere in this issue, was Mr. Froude's principal service to the world.

Once established, towing tanks have become an important and almost indispensable adjunct to the leading navies of the world and also to the private shipbuilder. Besides the tanks owned by different countries and by shipbuilders, which are usually supplied with very complete and expensive equipment, a number of smaller tanks have been established at various engineering schools where naval architecture is taught. While the equipment of these tanks is less elaborate, the work carried out at them is often of the greatest value, because, unhampered by commercial considerations, they are available for a great amount of valuable research work.

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Progress of Naval Vessels.

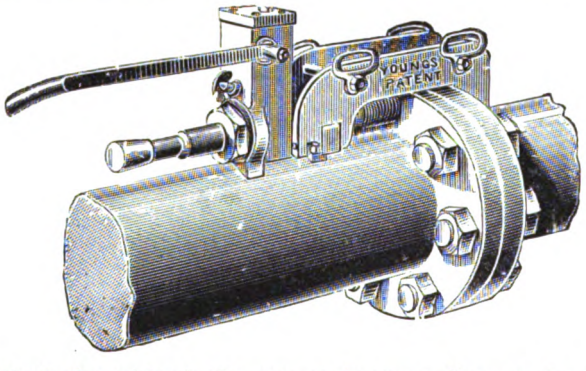
The Bureau of Construction and Repair, Navy Department, reports the following percentages of completion of vessels for the United States navy:

	Tons.	Knots.		Nov. 1.	Dec. 1.
BATTLESHIPS.					
S. Carolina..	16,000	18½	Wm. Cramp & Sons.....	65.9	69.9
Michigan ...	16,000	18½	New York Shipbuilding Co..	74.9	79.4
Delaware ...	20,000	21	Newp't News S.B. & D.D. Co.	50.3	54.9
North Dakota	20,000	21	Fore River Shipbuilding Co..	58.8	62.8
TORPEDO BOAT DESTROYERS.					
Smith	700	28	Wm. Cramp & Sons.....	57.5	59.9
Lamson	700	28	Wm. Cramp & Sons.....	56.2	58.5
Preston	700	28	New York Shipbuilding Co...	52.0	54.9
Flusser	700	28	Bath Iron Works.....	33.0	40.9
Reid	700	28	Bath Iron Works.....	31.6	38.5
SUBMARINE TORPEDO BOATS.					
Stingray ...	—	—	Fore River Shipbuilding Co..	62.3	64.5
Tarpon	—	—	Fore River Shipbuilding Co..	60.3	63.0
Bonita	—	—	Fore River Shipbuilding Co..	57.8	60.8
Snapper	—	—	Fore River Shipbuilding Co..	56.5	58.2
Norwhal ...	—	—	Fore River Shipbuilding Co..	52.3	54.8
Grayling ...	—	—	Fore River Shipbuilding Co..	52.0	53.5
Salmon	—	—	Fore River Shipbuilding Co..	51.3	52.8

ENGINEERING SPECIALTIES.

Youngs' Patent Hollow Ram Hydraulic Bolt Forcer.

Youngs' patent hollow ram hydraulic bolt forcer is constructed principally for forcing in and out coupling bolts, but it is also suitable for various other purposes, such as forcing pins, etc., in and out of machines, and removing drums from the shafts of winches when fitted with a special crosshead and bolts. The novelty of the invention consists in having a hollow steel sliding ram, the ends or tails of which project through the front and back respectively of the cylinder. Inserted in this hollow ram is a steel drift, which passes right through the center of ram; a head is forged on one end of the steel drift, a shoe for the bolt is fitted on the other. The

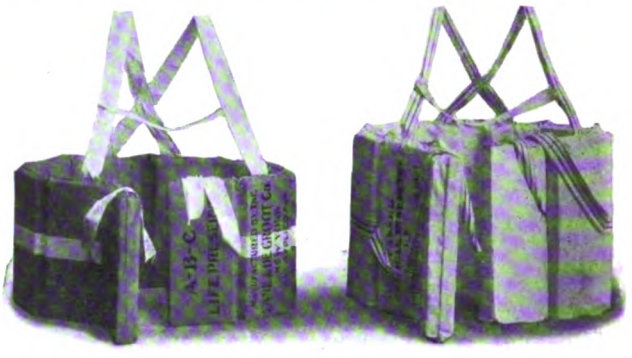


method of working is the same as in any ordinary hydraulic pump, viz.: the fluid is forced by the pump from the reservoir into the cylinder, and the ram is gradually forced forward until it presses the shoe, on the end of the steel drift, against the bolt to be forced out. Should the bolt show no sign of moving out of the coupling when the maximum hydraulic pressure has been obtained, a sharp blow is given with a hammer on the head of the drift, which transmits a shock or "jar" to the bolt and starts it from its position, and it can then be ejected either by pumping the ram forward or knocking it out by hammering on the head of the steel drift. Thus the device combines both the push and the blow or "jar." A release or stop valve is provided for the return of the liquid to the cistern, after unscrewing which the ram can be pushed back ready for another stroke. Another valuable feature consists in the easy portability of the machine, which is a great consideration in shaft tunnels or other cramped spaces; for this purpose the body can be separated from the arms or claws by withdrawing two sliding bolts, when the machine can be carried in two separate pieces and the body placed first in position on the shaft and the claws lifted up afterwards.

These machines are manufactured by Youngs, Ryland street works, Birmingham.

The A B C Life Preserver.

A new life preserver is soon to be placed on the market by the Lane & De Groot Company, of New York. This life preserver, as shown in the photograph, is made in the same way as the old-style cork preserver, with the exception that the cloth cover and straps are of better quality and the stitching is more carefully done. The principal feature of this preserver is, of course, the means employed for obtaining the required buoyancy. The manufacturers have made use of a material which is about one-third lighter than cork. They have,

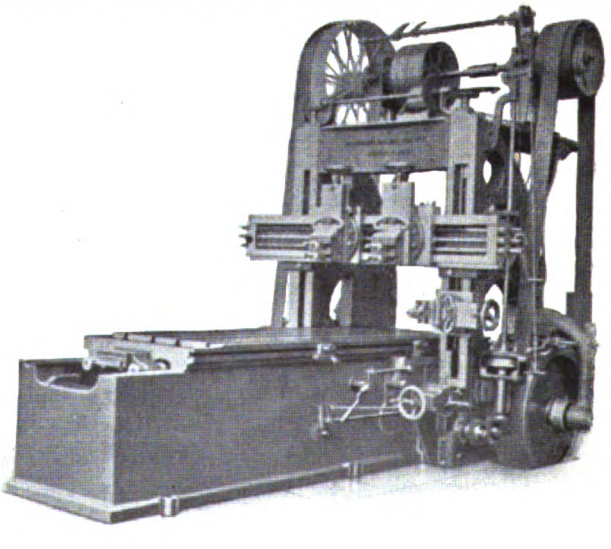


A B C BELT. CORK BELT.

therefore, been able to reduce the size of the life belt very materially, and, of course, the weight is reduced a corresponding amount, while maintaining a greater buoyancy than with the ordinary cork belt. The material used in the belt is coated with a solution which entirely prevents water or dampness from the atmosphere from being absorbed. It is also fireproof. The advantage of having a waterproof material is, perhaps, the most important, as far as the life of the belt is concerned, since this preserves the covers and straps from mildew and rot. This life preserver has been approved by the Board of Supervising Inspectors; and, due to its many advantages, will undoubtedly be widely used.

The Bateman "Top Speed" Planer.

A combination of high speeds and accurate work in planing has been sought in the design of the Bateman top-speed planer, manufactured by the Bateman's Machine Tool Company, Ltd., near Hunslet, Leeds. The bed of the planer is of heavy design, thoroughly stayed, and is about 75 percent longer than



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the stroke of the table. The table itself is deep and well ribbed, the ways being accurately planed and scraped. It is provided with longitudinal T-slots and stop holes, and is fitted with a patented buffer sliding rack, which enables it to be run at high speed and reversed promptly without shock or jar and without damage to the gears. In order to resist the heaviest cuts at high speeds the housings are made of strong design, and the faces afford large bearing surfaces for the cross slide. The cross slide is of sufficient length to carry two tool boxes, both of which travel the entire width between the housings, and have horizontal and vertical feeds in both directions independent of each other. Each tool box is provided with a full swivel index from zero to 60 degrees, the down-feed being fitted with micro adjustment. The automatic feed is of the friction type, and can be started, stopped or changed while the machine is in motion, the pressure on the friction cone being adjusted by means of a spring. All gears used on the machine are cut from solid blanks and the sliding rack is cut from a solid steel slab. The machine is driven at both sides from a countershaft carried on the housing brackets. The patent fly-wheel loose pulleys (with friction clutches between them and the fast pulleys and overlapped by the driving belts) secure exceptionally prompt reversal of the table with great economy of power at the moment of reversal. It is claimed that this patent fly-wheel drive secures such promptness of reversal that the machine will cut to a mark with great precision, the stored energy of the fly-wheel insuring a reliability not always obtainable.

Heat Non-Conducting Material.

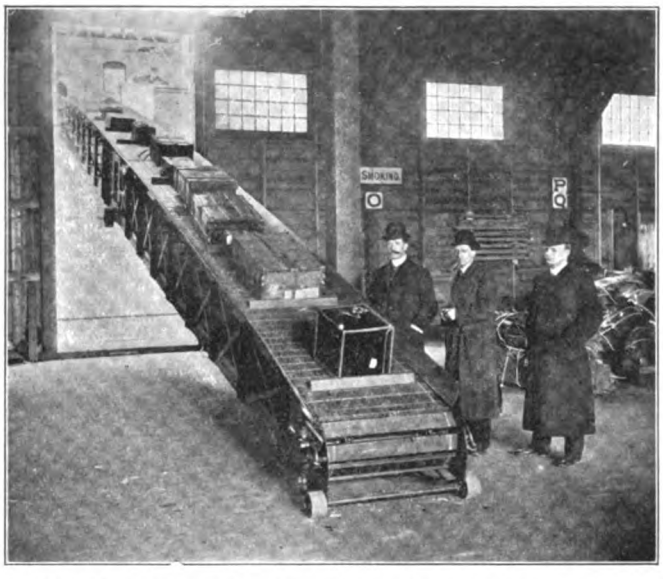
In any steam plant economy in fuel consumption is largely affected by radiation, not only from the boiler but from the steam pipes as well. Loss of heat by radiation can be very largely reduced by the use of a good non-conducting covering for the boilers and steam pipes. Whether this will be an advantage or not depends largely on whether the material used for the covering is efficient and durable.

Messrs. Matthew Keenan & Company, Ltd., Tredegar Road, Bow, London, E., have for the last fifty years been making a study of heat insulating materials, and now have on the market as the result of this experience a patent composition for which high efficiency is claimed. On several ships, the boilers of which have been covered by this composition, tests

have been made by the superintending engineers, showing that with a steam pressure of 215 pounds the temperature of the covering was only 4 degrees higher than that of the surrounding atmosphere, which means not only a great saving of fuel but also enables the stokers and coal passers to work in greater comfort. This composition does not require a sheet iron covering on the outside, as it dries to a hard surface. A small mesh-wire covering is placed over the composition, or just under the finishing coat. Should a leak occur in the seam of the boiler, its position will be shown at once, and the wire can then be cut and turned over, the insulation taken out and the seam calked. Afterwards the material can be dampened and put on again, and, after drying, the wire can be placed back in position. The usual method of applying the material, as shown in the illustration, is in three coats, with the wire netting just under the finishing coat. The advantage of using an insulating material which does not require a sheet iron covering is that it enables the engineers to detect leaks and repair them; it keeps the stokehold at a much lower temperature, and a saving in weight of 2½ pounds per square foot is obtained, assuming that galvanized iron of 16-gage would be used for a sheet iron covering.

Spence Portable Electric Conveyors.

Spence conveyors are built of steel frames tapering from the center to the ends, so braced as to give maximum strength with a minimum weight of material. There are roller-bearing steel sheaves on which a flexible steel cable runs, carrying an endless platform, or hardwood apron. It is claimed that this arrangement reduces friction greatly and minimizes the power



needed to operate the conveyors. The conveyors are reversible, so that boxes, sacked goods, barrels, etc., may be taken either up or down. A self-registering counter can also be attached when desired. Extension conveyors are made which can be connected in series and driven from the initial conveyor. Such conveyors can be placed between warehouse or dock floor joists to run flush with the floor, and thus allow trucking back and forth without interference. The illustration shows a 50-foot Spence conveyor loading baggage on the Cunard steamship *Mauretania*.

The headquarters of the Spence Manufacturing Company are at St. Paul, Minn.

The New Union-Cinch Pipe Fitting.

It is not an easy matter to make a neat job of pipe fitting with small piping where ordinary threaded pipe and tapped fittings are used. Where the work of threading the pipe and getting a good fit for the threads can be accomplished at a factory or in the shop, it is reasonable to expect that the work will be more satisfactory than when done by inexperienced workmen in the field without proper facilities.

The Union-Cinch pipe fitting, manufactured by the Sight Feed Oil Pump Company, Milwaukee, Wis., was designed so that the work of threading could be done in the shop rather than in the field, so that the only tools required in the field are a hack-saw and monkey wrench, except where some complicated bends are to be made when a pipe-bending device of

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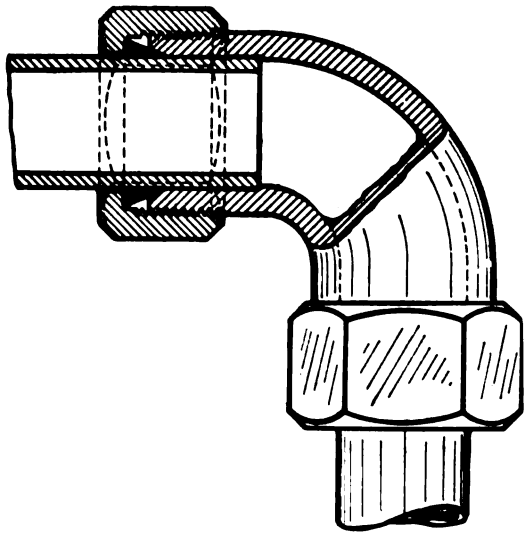
some sort is necessary. Each fitting is a union, so that the piping may be taken down at any point where a fitting is inserted. The type of joint is clearly shown in the illustration. The joint is made by screwing down the outside nut, which presses a thin, tapered shell into an annular cavity around the pipe between it and the fitting. After these nuts are set up tightly the soft cone shell will make an absolutely tight joint around the tubing, capable of withstanding any pressure which the tubing will stand.

These fittings are made in sizes corresponding to standard iron pipe up to 1 inch, and are especially designed for use in connection with the oil pumps and oilers manufactured by the



Sight Feed Oil Pump Company. It is possible, however, to use ordinary rough pipe with these fittings if care is exercised in filing the ends of the pipe round and smooth, but the manufacturers of the fittings are prepared to furnish smooth-drawn steel tubing corresponding to the iron pipe sizes on the outside diameter. This tubing has a 16-gage wall in the ¾ and 1-inch sizes, and an 18-gage wall in the smaller sizes. This pipe, therefore, has a very much larger carrying capacity than ordinary pipe. In fact, the manufacturers claim that their ⅛-inch pipe will carry almost as much as the ordinary ¼-inch iron pipe. Where it is desirable to have a nice-looking job, brass pipe may be used, although in cases where nickel plating is done a steel tubing will nickel-plate just as well as brass pipe, and is much cheaper.

These fittings are especially valuable in such troublesome work as piping up oil pumps, gravity oiling devices, gages, drop pipes, etc., and especially in work around ammonia-handling machinery, where perfectly tight joints are essential against the escape of ammonia gas.

QUERIES AND ANSWERS.

Questions concerning marine engineering will be answered by the Editor in this column. Each communication must bear the name and address of the writer.

Q. 491.—What is the meaning of the word inverted as used in the expression "three-cylinder vertical, inverted, direct-acting, triple-expansion engine"? J. H. S.

A.—In the early days of marine engineering engines were often horizontal; an intermediate type, known as the inclined or diagonal engine, is now used to a considerable extent in paddle-wheel steamers, but in modern practice nearly all reciprocating marine engines are vertical. In the earlier vertical marine engines the cylinder was at the bottom, and the motion of the parts proceeded upward either directly to the crank shaft, as in an oscillating engine, or to a beam or intermediate mechanism, whence it came back to the shaft. In the modern engine the cylinders are on top, and the motion of the parts proceeds downward to the shaft. Hence, in comparison to the earlier types, the modern engine is called inverted.

TECHNICAL PUBLICATIONS.

Knocks and Kinks (*Power* Hand-Book Series). By Hubert E. Collins. Size, 4½ by 6¾ inches. Pages, 137. Figures, 82. New York, 1908: Hill Publishing Company. Price, $1.

This book, which is arranged in convenient size for the desk or pocket, and which has been written especially for the operating engineers, contains the results of the experience of a number of practical men in locating knocks in engines and the kinks to which they have resorted for eradicating the knocks. Most of the common causes of knocks are given, and many which are not so common, but none the less valuable for an engineer to know. The means of detecting the cause of knocks and the remedy to be applied is the chief object of the book. Many interesting instances are given covering both marine and stationary practice.

Machine Shop Calculations. By Fred H. Colvin. Size, 4½ by 6¾ inches. Pages, 174. Figures, 96. New York, 1908: Hill Publishing Company. Price, $1.00.

The calculations described in this book may seem somewhat elementary to many, but will be found invaluable by the man in the shop who has had limited opportunities for education. Everything is described with a view to its application to machine work. Such subjects as the speed of pulleys and gearing, screw-thread calculations, taper work, speed of lathes, planers and shapers, measuring surfaces and volumes of solid bodies, angles, the use of the vernier and micrometer are fully described and illustrated. The final chapter is on the uses of shop "trig," and is followed by a set of trigonometrical tables.

Logarithms for Beginners. By Charles M. Pickworth. Second edition. Size, 5 by 7¼ inches. Pages, 47. New York, 1908: D. Van Nostrand & Company, 23 Murray street. Price, 50 cents net.

In this edition the subject-matter has been slightly revised and a few numerical errors corrected. The book should be a valuable aid to beginners, who find difficulty in grasping the root principle of calculating by means of logarithms. The explanation of logarithms is far more detailed and practical than is usually found in text-books.

Elementary Dynamo Design. By W. Benson Hird. Size, 5¼ by 8¼ inches. Pages, 280. Figures, 128. London, E. C., 1908: Cassell & Company, Ltd. Price, 7/6 net.

Use is made of numerical examples in this volume to illustrate the methods and calculations necessary for the design of dynamo electric machinery. No attempt has been made to go into the controversial points as to the nicety of design, as the book is intended as an elementary treatise. The introductory chapters treat briefly with such points of the theory of electricity and magnetism as are most intimately connected with dynamo design. This is done in order to enable those who take up the subject from the practical side without extensive theoretical training to follow intelligently the reasoning in the succeeding chapters. After describing the various types of dynamos and motors, the question of designing a

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continuous-current generator is taken up and the necessary calculations are explained by numerical examples, following which is a discussion of the continuous-current motor. Chapter V. takes up the mechanical details, such as the shaft, bearings, armature spider, commutator construction and brush holders. The general requirements for continuous-current dynamos and motors for special purposes are given some attention. The remainder of the book is taken up with the subject of alternating currents, the design of the three-phase generator, the three-phase induction motor and other varieties of alternating-current motors.

Pipes and Piping (*Power* Hand-Book Series). By Hubert E. Collins. Size, 4½ by 6¾ inches. Pages, 140. Figures, 75. New York, 1908: Hill Publishing Company. Price, $1.

General rules for the design of both high and low-pressure steam piping for power plants are the basis of this work. The reader is given ideas as to the forces to be met and the amount of resistance that can be expected from the pipe and fittings when properly placed. The best arrangement of steam piping for any size plant is given, together with many useful suggestions as to the installation and operation of the system. Expansion and contraction and evaporation in steam pipes are subjects with which the designer must be thoroughly familiar. These subjects are carefully discussed, after which high-pressure steam pipe flanges and methods of packing flanged joints are considered.

Bureau Veritas, 1908-1909. Thirty-ninth year. General list of merchant shipping. Two volumes, steamers. Size, 10 by 7½ inches. Pages, 1,700. Sailing vessels. Size, 7¼ by 9¾ inches. Pages, 1,300. 1908: Paris, 8 Place de la Bourse. London, 155 Fenchurch street, E. C. Price of complete work, £3 3/ ($15). Steamers, £1 15/; sailing vessels, £1 10/.

This well-known publication contains the customary statistics regarding the merchant shipping of all nations, besides a complete list of steamers and sailing vessels in which the principal dimensions, tonnage, builders, construction, mode of propulsion, horsepower and type of propelling machinery and the name and address of the owners are given. There are tables showing the number of ships built, bought and sold in the principal countries during the year; lists of steamers, the names of which have been changed; lists of steamers carrying petroleum in bulk; and a list of cable vessels. There are also alphabetical lists of steamers arranged according to tonnage, and of iron and steel shipbuilders arranged according to nationality, and of steamship owners arranged according to nationality, with the names and gross tonnages of their steamers. A complete list is also given of the drydocks, patent slips and floating drydocks in all parts of the world.

The Mechanical World Pocket Diary and Year Book for 1909. Twenty-second annual issue. Size, 4 by 6 inches. Pages, 395. Figures, 60. Manchester: Emmott & Company, Ltd. Price, 6d. net.

The improvements effected in this year's issue of the *Mechanical World Pocket Diary* include the complete revision and extension of the section on steam turbines, so as to deal more adequately with recent developments in this important branch of steam engineering. The section on friction clutches has also been rewritten and made more comprehensive. A section on chain driving has been introduced, also a note on the graphic calculation of moments of resistance of beams, and tables of the values of I and Z for various sections have been restored. The entire work forms a comprehensive mechanical engineer's handbook, including most all of the mathematical tables for which there is use in current practice.

The Mechanical World Electrical Pocketbook for 1909. Second annual issue. Size, 4 by 6 inches. Pages, 279. Figures, 63. Manchester: Emmott & Company, Ltd. Price, 6d. net.

As this is a book which is published annually, each year will find it enlarged and revised, to include new matter in order to bring it up to date. This year's issue contains valuable data on electric bells and bell circuits, transformation of currents, motor generators, rotary converters, alternate current or static transformers, cables, fuses, circuit breakers, balancers, boosters, electric lifts, electricity in mines, flexible shaft couplings, etc. At the end of the book are mathematical tables for which daily use is found by the electrical engineer, and a complete diary for the year.

Erecting Work (*Power* Hand-Book Series). By Hubert E. Collins. Size, 4½ by 6¾ inches. Pages, 140. Figures, 110. New York, 1908: Hill Publishing Company. Price, $1.

Starting with the subject of foundations, much valuable information is given regarding the best methods of erecting the various items of machinery which are installed in a power plant. The book is thoroughly practical and goes into such detail as the subjects of knots and hitches; the best method of hauling heavy machinery through city streets, and gives the reader an idea of the usefulness of inclined planes, gin poles and various types of rigging for lifting and handling weights. A description is given of the methods of building up a flywheel, and, finally, of erecting a high-speed center-crank engine, together with some incidental lighter work.

Obituary.

Warren Eden Hill, president of the Continental Iron Works, Brooklyn, died at the Hotel Florence, Brooklyn, N. Y., Dec. 8. Mr. Hill was seventy-four years old, and had been identified with the engineering profession since 1852, when he became associated with the Allaire Iron Works, in Newark, N. J. From 1858 to 1862 Mr. Hill was superintendent of the installation of the Detroit water works, and since then he has been associated with the Continental Iron Works of Brooklyn.

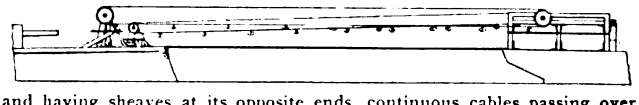
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney. Loan & Trust Building, Washington, D. C.

903,094. APPARATUS FOR COALING SHIPS AT SEA. ANDREW JOHAN, OF NEW YORK, N. Y.

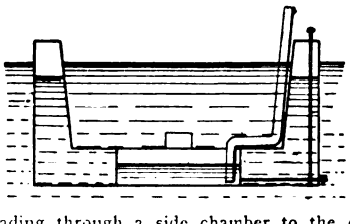
Claim 1.—In an apparatus for transferring at sea material from one ship to another, the combination of sheaves carried by one of the ships, a cross-beam slidably and swingingly mounted, carried by the other ship,



and having sheaves at its opposite ends, continuous cables passing over the sheaves from one ship to the other, on which the material is carried, and a weight connected to the cross-beam for equalizing the strain on the cables and maintaining them under constant tension. Eight claims.

903,215. FLOATING DOCK. ALFRED MEHLHORN, OF DIETRICHSDORF, AND PHILIPP VON KLITZING, OF NEUMUHLEN, NEAR KIEL, GERMANY.

Claim.—A floating dock comprising side chambers, a bottom central pontoon forming an air-chamber, a valved pipe communicating with said



pontoon and leading through a side chamber to the exterior, and an air-tube communicating with said valved pipe and provided with an air-valve. One claim.

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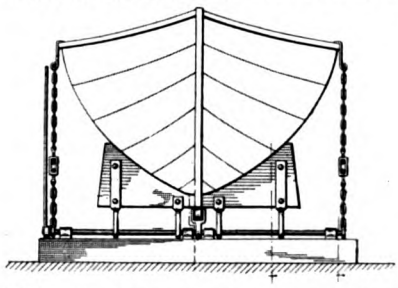
903,025. BOAT-HANDLING DEVICE. LEWIS TANNING AND WILLIAM J. RYAN, OF NEW YORK, N. Y.

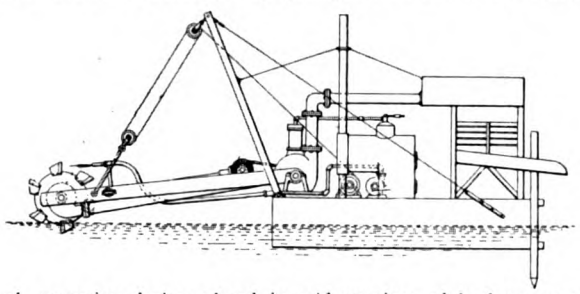
Claim 1.—The combination of a boat provided with a keel and with brackets mounted upon said keel, forks mounted independently of said



boat and provided with rollers for engaging said keel and also for engaging said brackets, and means controllable at will for turning said forks. Three claims.

903,210. DREDGER-CUTTER. ALFONSO LKIEVICZ, OF BERKELEY, CAL.

Claim 2.—In a dredger, a float, a ladder hinged thereto, a cutter consisting of a revolving wheel, digging buckets carried on the periphery of said wheel, said buckets having openings on the side toward center of



wheel, screening devices placed in said openings of buckets, passageways through cutter wheel leading from said openings in digging buckets to side outlet or outlets, a suction chamber to receive the material and a suction pipe connected therewith. Seventeen claims.

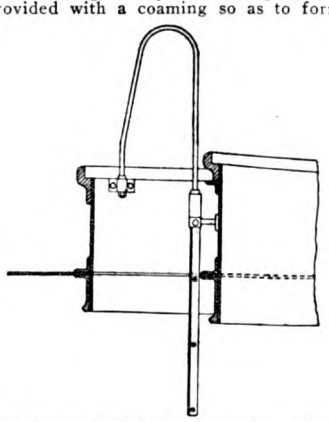
British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

8,530. FURNACES. S. J. ROSS, LONDON; H. SCHOFIELD, MIDDLESEX.

Ordinary steam boilers are provided with means whereby combustion in the furnace is conducted under pressure, which is maintained throughout the combustion chamber and smoke tubes. The front of the furnace and ash pit is closed, compressed air being supplied through a pipe and air-heating passages in the furnace front to the ash pit. The smoke tubes discharge into a box or casing inclosed at the front by a hinged plate to the bottom of which is hinged a counterweighted flap. The flap closes the outlet of the casing and opens more or less according to the rise or fall of pressure.

12,345. SHIPS' LADDERS. H. M. GRAYSON, LIVERPOOL.

A ladder for gaining access to the holds of a ship is secured to the outside of the hatch coaming, and passes through a hole in each deck, this hole being provided with a coaming so as to form a raised man-



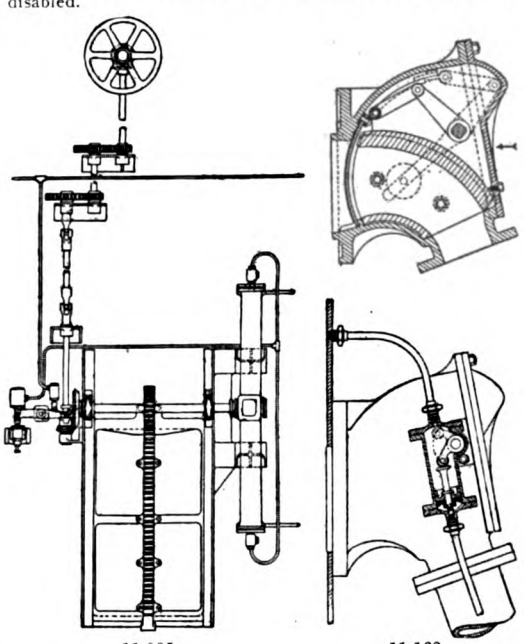
hole. The coaming has a rabbeted upper edge adapted to receive a covering or door. Removal hand-rails fit into sockets secured to the top of the ladder, and to the inside of the coaming. The sides of the ladder are formed of angle, channel, or other bars. A ventilator, such as a cowl, may be placed upon the entrance of the upper man-hole coaming, so that this man-hole serves as a conduit for conveying air into or from the holds.

11,041. PREVENTING CORROSION OF SHIPS' PROPELLER SHAFTS. R. DERENBACH AND RUSSIAN-AMERICAN INDIA RUBBER CO., ST. PETERSBURG, RUSSIA.

A protective covering of rubber is applied to the propeller shafts of ships, in combination with other materials, the cohesion of which is greater than their adhesion to the shaft. For example, the hollow shaft of a ship has its ends closed by blind flanges, and it is warmed up from the inside with steam, and then wound with rubbered or otherwise prepared strips of fabric or plaited material, or rubber composition, with embedded matter. A layer of rubber composition is then ironed on, and the steam pressure is increased until the shaft is brought to a vulcanizing temperature. In covering a solid shaft, the shaft is heated before the fabric strips are wound on, and, after the layer of rubber is put on, the whole is placed in a vulcanizing jacket.

11,095. SHIPS' BULKHEAD DOORS. J. McDONALD, CLYDEBANK, GLASGOW.

Each door is normally actuated by hydraulic pressure, and a clutch is fitted which is capable of automatically engaging or disengaging hand operating gear. When the hydraulic gear is in use the ram acts on the pivoted lever and withdraws the sliding portion of the clutch, and so disengages the hand-operating gear; should the pressure in the pipe suddenly fail, however, a spring in the clyinder throws the parts of the clutch into re-engagement, bringing the hand gear into operation again. A second and smaller ram, connected by a pipe to the main, throws the hand-operating mechanism into gear immediately the hydraulic operating gear is disabled.



11,095. 11,162

11,162. SHIPS' SEA COCKS. F. J. TREWENT AND W. E. PROCTOR.

Hydraulic power is employed to open the sea cock of an ash ejector. The sliding valve is connected by links to a spindle, on which is an arm provided with an anti-friction roller, and is operated to turn the spindle by means of a rod connected to the plunger of an hydraulic cylinder. The latter is connected by a branch pipe to the water supply to the ejector, the connection being made at a point between the pump discharge and the ejector cock. A three-way cock is disposed in the branch pipe to enable the cylinders to be placed either in communication with the water supply to the ejector, or with a waste pipe. The exit end of the ejector pipe is formed of renewable segmental and side pieces. A counterbalance weight on the spindle closes the door, when the piston of the hydraulic cylinder returns to its normal position.

11,489. MARINE LIFE-SAVING APPARATUS. A. J. MACLEOD, WEST HARTLEPOOL.

The line connected to the shore by means of a gun firing a projectile is secured to the mast of a ship above a platform, to which persons and articles on deck are lifted in a cradle guided against the mast by guide ropes. The fine connecting line fits in a longitudinal recess in the projectile, and is attached to a ring lying in a recess at its end. The projectile is preferably made of copper, and is hollow.

11,680. SHIPS; PROPELLING BY WATER JETS. C. R. DARLINGTON, LLANBRADACH.

A tube extending the length of a ship is bifurcated at its fore part, and a propeller is placed at the rear of the junction of the two branches. This tube, which is fitted with sluice valves, may be connected to the various compartments, and may be fitted throughout the whole or part of its internal surface with helical ribs formed of angle bars.

12,386. SHIPS. H. A. MAVOR AND MAVOR & COULSON, GLASGOW, AND J. H. BILES, WESTMINSTER.

A turbo-generator plant is employed for supplying the power in vessels carrying derricks, winches and other auxiliaries requiring considerable power, the power generated being used entirely for propulsion, partly for propulsion at a reduced speed, and partly for the auxiliaries, or wholly for the auxiliaries as required. The weight and capacity of the generating plant are thus reduced to a minimum. As applied to a sand-pumping dredger, an alternating current generator, governed to run at a regular, but adjustable, speed by electric means—for example, by a reversible motor driven by an independent circuit, connected with the steam valve—supplies current to the various motors or groups of motors as required for propelling or for driving the pumps and other auxiliaries, which motors may have their stators incorporated in the structure of the vessel. In vessels requiring a variable speed the speed may be regulated by regulating the periodicity of the generator by employing several generators of different periodicity connected up with moors of corresponding periodicity, or by employing motors with revoluble stators which can be positively or negatively driven.

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